UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN 418

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER February 6, 1917

WESTERN YELLOW PINE IN OREGON

By

THORNTON T. MUNGER, Forest Examiner

CONTENTS

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By THORNTON T. MUNGER, *Forest Examiner.*

CONTENTS.

INTRODUCTION.

Western yellow pine[1] (*Pinus ponderosa* Laws.) is known throughout its range simply as pine or yellow pine, and in the lumber trade of the Northwest as western pine. It is sometimes called western soft pine or, more rarely, Oregon white pine. The terms used by California lumbermen are "western white pine" and "California white pine."

It is the most widely distributed pine in the United States and one of the most valuable. It is suited to a great variety of uses and throughout much of its range supplies nearly every local need. Its large size, good form, occurrence in large and easily accessible bodies, and the high technical qualities of its wood place it near the top of the list of commercially important American timber trees. The reported cut in the United States in 1915 was 1,252,244,000 feet, which places yellow pine seventh in rank if the oaks are considered collectively. California leads the States, with a cut (in 1915) of 389,991,000 feet, and Oregon is third with an annual output of 189,203,000 feet. There is estimated to be in the United States

[1] Seven distinct species of pines occur naturally in the State of Oregon: (1) western white pine (*Pinus monticola*), the "Idaho white pine" of the markets, a valuable timber tree found in Oregon in rather limited quantities, chiefly in the mountains; (2) sugar pine (*Pinus lambertiana*), the important timber tree of California, which in Oregon occurs chiefly in the Cascades and other ranges in the southwestern part of the State; (3) white bark pine (*Pinus albicaulis*), a small, scrubby tree found on mountain tops throughout the Northwest; (4) knobcone pine (*Pinus attenuata*), a small tree of almost no commercial importance, which is found here and there in dry situations in the southwestern portion of the State; (5) lodgepole pine (*Pinus contorta*), also locally called black pine, jack pine, and shore pine, a small yet extremely hardy and aggressive tree that grows on both the coastal strip and nearly up to timber line on the mountains and covers vast areas of plateau in the central part of the State with pure stands of small trees; (6) Jeffrey pine (*Pinus jeffreyi*), a timber tree of the Siskiyou Mountains and California, which strongly resembles western yellow pine; and (7) western yellow pine (*Pinus ponderosa*).

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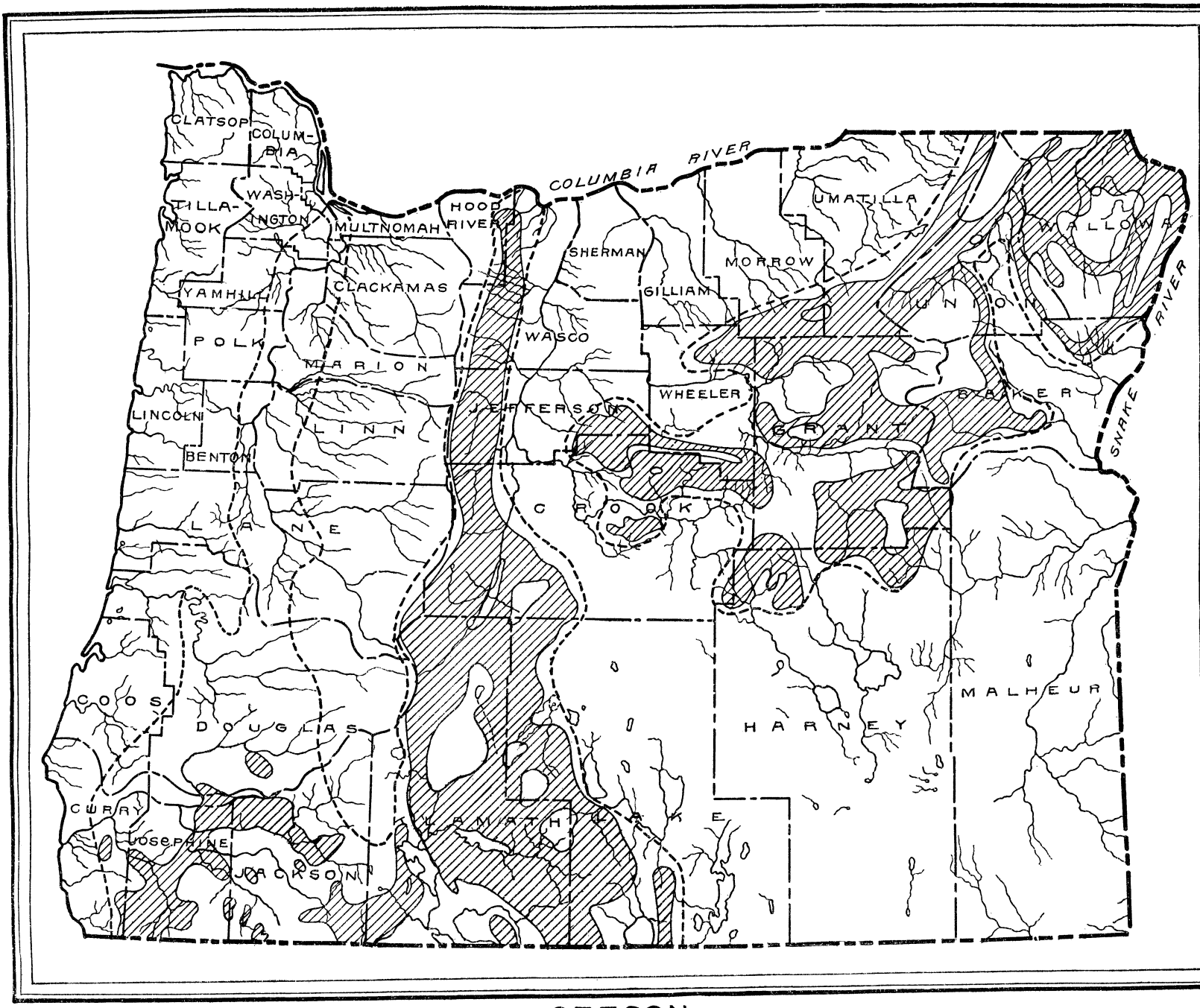

OREGON

▨ Commercial Forest of Yellow Pine

--- Limits of its botanical range

400,000,000,000 feet of this pine, more than there is of any other single species except Douglas fir. The annual cut is less than 0.004 of the stand.

Western yellow pine occurs naturally from southern British Columbia to Lower California and northern Mexico, and from the Pacific coast nearly as far east as to the one-hundredth meridian. It is found in the forests of every State west of the Great Plains, and in more than half of them it is the most important and valuable forest tree. In Arizona and New Mexico there is a western yellow pine forest which is said to be the largest continuous body of timber in the country.

DISTRIBUTION AND ABUNDANCE IN OREGON.

Of the 12 States in which western yellow pine occurs, California has the largest area of forests composed chiefly of this species, and Oregon comes second. Together these two States contain nearly 50 per cent of the area of commercial yellow-pine forests, and probably as large a proportion of the merchantable timber. Western yellow pine occurs on about 14,000,000 acres in Oregon, practically a quarter of the State and half of its timbered land. Of this area about 10,000,000 acres may be classed as commercial forest, the estimated stand amounting to 70,000,000,000 feet, or an average of 7,000 feet per acre, inter-forest waste areas included. Although the yellow-pine forests cover a larger proportion of the State than do the Douglas-fir forests, the fir stands are so much denser that the estimates show four times as much Douglas fir as they do yellow pine. The yellow pine amounts to from 15 to 20 per cent of all the commercial timber.

The distribution of yellow pine in Oregon is shown in Plate I. The areas of commercial forest, in which yellow pine forms at least 25 per cent of the stand and in which the quantity is large enough to be logged profitably, are shown in the shaded portions. The botanical range is indicated by a dotted line. The species is found from Bonneville on the Columbia River eastward to Idaho and southward to California through all the timbered portion of the State east of the Cascade Mountains. North of the Umpqua River and west of the Cascades it occurs only in small stands in the Willamette Valley. The altitudes at which it is found range from the lowest zone of forest growth on the borders of the sagebrush desert, the "dry timber line," which is at from 2,500 to 3,500 feet in eastern and central Oregon, up to 5,000 or 6,000 feet (scattered individual trees even going to 8,000 feet) on the slopes of the mountains. At this height the humidity is greater and the yellow pine gives way to a forest of moisture-demanding species. In the southwestern part of the State yellow pine occurs abundantly on the west slopes of the Cascade and Siskiyou Mountains, from the valley floors to altitudes of 6,000 feet, particularly in warm situations.

The important yellow-pine land of the State may be grouped into three sections: (1) The *Blue Mountain* region, embracing all the timbered land in the northeast quarter of the State, an area that is practically surrounded by treeless country and to a large extent consists of rolling hills; (2) the *eastern slope of the Cascades* and their outstanding ranges, a zone of mountain tops and plateaus, which is bordered on the west by the summit of the range and on the east by desert, and on which yellow pine forms 80 per cent of all the commercial timber; (3) *southwestern Oregon*, embracing the Siskiyou Mountains and the western foothills and slopes of the Cascades south of the Umpqua River. The timber in these regions is distributed as follows:

Regions.	Acres of commercial yellow pine.	Total stand in thousands of feet b. m.
Blue Mountains	4,276,000	31,350,000
East Slope Cascades	3,400,000	33,185,000
Southwest Oregon	2,330,000	6,830,000
Total	10,006,000	71,365,000

Most of Oregon's 70,000,000,000 feet of yellow pine occurs in 10 counties, each of which has over 1,500,000,000 feet b. m. and 300,000 acres of commercial yellow-pine timberland. In the order of the volume of their standing yellow pine, the counties are thought to rank as follows: Klamath, Crook, Lake, Grant, Jackson, Wallowa, Baker, Wheeler, Harney, and Union. Table 1,[1] prepared in 1912 and 1913, indicates the acreage and amount of yellow pine in private and in Government ownership for the counties in which it occurs in commercial quantities.

TABLE 1.—*Ownership and stand of yellow pine in Oregon, by counties.*

County.	Privately owned yellow-pine timberland.		Government yellow-pine timberland.[2]		Total	
	Acres.	*Feet b. m.*	*Acres.*	*Feet b. m.*	*Acres.*	*Feet b. m.*
Baker	213,168	1,536,000,000	306,064	1,345,000,000	519,232	2,881,000,000
Crook	535,346	6,847,900,000	638,115	6,415,000,000	1,173,461	13,262,900,000
Curry	59,520	45,400,000	493,721	55,300,000	553,241	100,700,000
Douglas						[3] 20,000,000
Grant	301,820	2,853,000,000	884,200	5,315,000,000	1,186,020	8,168,000,000
Harney	36,960	339,000,000	315,335	2,285,000,000	352,295	2,624,000,000
Hood River	6,000	18,000,000	4,000	12,000,000	10,000	30,000,000
Jackson	592,751	5,431,000,000	31,840	223,000,000	624,591	5,654,000,000
Josephine	773,927	721,600,000	363,327	296,800,000	1,137,254	1,018,400,000
Klamath	836,750	7,393,000,000	994,000	10,725,600,000	1,830,750	18,118,600,000
Lake	301,539	3,340,000,000	569,232	5,500,000,000	870,771	8,840,000,000
Lane					[4] 15,000	[4] 40,000,000
Morrow	112,200	777,000,000	25,000	143,000,000	137,200	920,000,000
Umatilla	32,200	275,000,000	35,000	233,000,000	67,200	508,000,000
Union	235,640	1,561,000,000	119,800	395,000,000	355,440	1,956,000,000
Wallowa	171,330	1,808,500,000	517,156	1,525,000,000	688,486	3,333,500,000
Wasco	40,000	280,000,000	145,000	920,000,000	185,000	1,200,000,000
Wheeler	198,875	1,586,000,000	101,690	1,101,000,000	300,565	2,687,000,000
Total	4,448,026	34,812,400,000	5,543,480	36,489,700,000	10,006,506	71,362,100,000

[1] From a compilation prepared largely by Forest Examiner R. M. Evans on the amount, distribution, and ownership of yellow pine in Oregon.

[2] All within the National Forests except that which is within the Klamath and Warm Springs Indian Reservations and the small amount owned by the State.

[3] Estimated; occurs as scattered trees.

[4] Estimated; occurs chiefly as scattered trees.

DESCRIPTION.

Western yellow pine is a large, well-formed timber tree.[1] In old trees the bole is usually straight and full-formed. It is well cleared of dead branches, but usually clothed with live branches for from one-half to two-thirds its height. The maximum diameter is 8 feet and the maximum height 220 feet.[2] The largest tree measured in the course of a volume study of over 2,500 felled trees in various parts of Oregon was a little over 6 feet in diameter at breastheight and the tallest was 177 feet high. The usual size at maturity is about 3½ feet in diameter and 110 feet in height. Table 2 gives the prevailing height of yellow-pine trees of various diameters in two regions of the State, one near Lookingglass Creek, Union County, growing exceptionally tall, fine timber, and the other near the edge of the desert at Bend, Crook County, where the timber is short. Most of the yellow-pine timber of the State would fall between these two extremes.

TABLE 2.—*Average total height of several hundred trees of various diameters on two sites, one exceptionally good for tree growth and the other poor.*[1]

Diameter at breastheight.	Total height.		Diameter at breastheight.	Total height.		Diameter at breastheight.	Total height.	
	Looking-glass Creek, Union County.	Near Bend, Crook County.		Looking-glass Creek, Union County.	Near Bend, Crook County.		Looking-glass Creek, Union County.	Near Bend, Crook County.
Inches.	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*	*Inches.*	*Feet.*	*Feet.*
12	71	.....	22	115	78	32	138	98
14	82	48	24	121	84	34	142	101
16	91	57	26	127	88	36	146	102
18	100	65	28	131	92	38	149	103
20	108	72	30	135	96	40	152	104

[1] In the Appendix are two volume tables which show the average contents in board feet of trees of various diameters and heights for two regions in Oregon. The average tree over 16 inches in diameter in the virgin stand contains about 1,000 board feet, and the average log about 250 feet. Trees with a volume of over 5,000 feet are very rare.

The bark of the trunk in young trees is dark gray-brown, roughly furrowed, and from 1 to 3 inches thick; in old trees it is tan colored (or "yellow"), is broken with rather large, irregular plates, and is commonly about 1 inch in thickness, and on very old trees even thinner. The crown is at first bluntly conical, but, as the tree matures, it becomes more and more roundheaded and bushy; on old trees it is quite flat-topped, and the upper branches are heavy and gnarled. The root system of mature trees consists of extensive, deep branching laterals which give the tree firm support. The foliage is not extremely heavy, so that the shade cast by yellow pines is not

[1] The forest characteristics of this tree vary decidedly in different parts of its wide range. The yellow-pine stands of the Black Hills are quite unlike those of the mesas of the Southwest, which are in turn unlike those of the eastern Oregon plateau or of the Sierra Mountains of California.

[2] Measured by John Muir in the Sierra Mountains of California.

dense. The needles are usually from 4 to 6 inches long, on the best soils as long as 11 inches; and they are borne in clusters of three.

The term "bull pine" is frequently applied to the younger yellow pines in an uneven-aged stand, usually those of rapid growth up to 18 or 20 inches in diameter and 100 or 150 years old. These immature, rapid-growing trees, or "bull pines," are quite different in appearance from the mature trees, or "yellow pines"; the bark of the young tree is much thicker, darker colored, and more furrowed; the crown s denser, longer, and more pointed; the wood is heavier, more sappy, and coarser grained; and the annual rings are more clearly defined. This has sometimes led to the belief that "bull pine" is a distinct species of pine, which it is not. Sometimes, particularly on wet soils, a tree will retain the "bull pine" characteristics to a considerable age and until it is 30 or more inches in diameter. The term "bull pine" is synonymous with the term "black jack," which is used in Arizona and New Mexico to denote young yellow pines; the relation between "bull" and "yellow" pine is analogous to that between "red fir" and "yellow fir" (the two types of the coast Douglas fir), or between "sapling pine" and "cork pine" (the two types of the Lake States white pine)

REQUIREMENTS.

CLIMATE.

Western yellow pine flourishes best in the heat and dryness of a continental climate, such as that on the interior plateaus and mountain slopes. In the north or on the highest slopes, where the growing season is cold, its development is much poorer than where the summers are long and warm. Though it shows a preference for sunny climates and warm situations, it can, however, endure severe winters and temperatures far below zero. In situations where it flourishes in central and eastern Oregon, the mean annual temperature goes as low as 42° F. and the mean summer temperature ranges from about 50° to 60° F., a maximum temperature of 100° F. being not uncommon.

Yellow pine will resist drought better than any other important commercial tree in the State. It forms splendid forests where the precipitation is only 18 inches a year and the summer dry season is long. Where the rainfall is but a little less than this the forest gives way to a treeless, sagebrush, or bunch-grass flora. Yellow pine also does well where the precipitation is much heavier—40 inches or more—but its development is by no means proportionately better in the wetter climates. It flourishes also in the mild, humid, insular climate of the Willamette Valley, which is almost the antithesis of that of the eastern Oregon yellow-pine ranges.

SOIL AND SOIL MOISTURE.

Western yellow pine grows and thrives on nearly every variety of soil within its range; it is one of the first trees to get a foothold on the disintegrating recent lava flows of central Oregon, and its ability to thrive on almost soilless steep talus slopes is remarkable. It grows also on loamy clay soils, on loose sand, and on the deep, light, fragmental pumice stone of central Oregon; but on cold, peaty, or heavy, moist soils, such as those adjacent to meadows, it is usually not found. It grows well on land which is too dry for any of its associates. It seems to prefer well-drained, loose soils; but an increase in moisture, provided the soil is well drained, makes for more rapid growth. Occasionally, but not usually, it grows on situations where the water table is within 4 or 5 feet of the surface during the growing season. It is, therefore, uncommon on flats and bottom land, and is distinctly a tree of the slopes. Exceptions occur, notably the form which occurs west of the Cascades in the Willamette Valley and which inhabits moist river benches.

LIGHT.

Stands of western yellow pine are always rather open because this tree is intolerant of shade. Seedlings do fairly well under the shade of parent trees, but saplings do not grow thriftily until they receive direct light. Western yellow pine is as intolerant as any of the trees with which it is associated in Oregon, and its reproduction can not compete successfully in the virgin forest with that of Douglas fir, white fir, or lodgepole pine on sites where the latter grow vigorously. With an increase in the amount of soil moisture, yellow pine becomes more tolerant of shade. The openness of most of the yellow-pine stands is probably due to the demand of the trees for soil moisture and the competition of the roots for ground space where moisture is insufficient, as well as to the demand for light and crown space.

REPRODUCTION.

SEED PRODUCTION.

Yellow pine after reaching middle age produces seed fairly abundantly. Trees under 50 years old, or 10 inches in diameter, rarely bear any cones; and large crops are not borne except by very much older and larger trees. Every three years, and sometimes oftener, come good seed years in which most of the adult trees in the stand bear seed; and in the intervening years there is usually some seed.[1] It is disseminated either by wind or by rodents that carry the cones or the seeds and store them. Sometimes many bushels of cones are

[1] For a full discussion of seed production of the yellow pine of the Southwest, see Forest Service Circular 196, "The Influence of Age and Condition of the Tree upon the Seed Production in Western Yellow Pine," by G. A. Pearson.

found in a squirrel cache. Undoubtedly a considerable proportion of the seed crop is eaten by animals, since the seed is large and attractive. In Oregon, yellow-pine seed is larger than it is farther east. The number of seeds to the pound from eastern Oregon trees is between 8,000 and 9,000. A bushel of unopened cones will usually yield about 1½ pounds of seed.

GERMINATION.

The seed germinates fairly freely, but in Oregon not until the spring following its dissemination. Laboratory tests of clean seed show that from 60 to 85 per cent of it is fertile, and that most of it germinates between four and eight weeks after sowing.

Field studies indicate that young seedlings are most abundant in the exposed spots in the forest, such as on scabby ridges, where the mineral soil is naked. Here germination may be the best, but the mortality of the seedlings the first year is the largest.

In certain parts of Oregon, particularly on the very dry pumice soils of the upper Deschutes Basin, it is noticeable that a very large proportion of the seedlings come up in clumps, from 2 to over 50 being crowded into a space as large as a half dollar. It has been suggested that these clumps originated where a cone accidentally became buried. But such is not the case in this particular locality. They have come from bunches of seed which were buried by provident chipmunks. (See Pl. II.) Some counts made in Crook County of the reproduction in the forest showed that 85 per cent of all the 1-year-old seedlings were in these chipmunk-sown groups. Much more seed must be sown broadcast by the wind on the surface than is accidentally left in these chipmunk caches, yet it is evident that the seed which is buried has a very much better chance of germination than that which lies on the surface. This is particularly so on the drier and looser soils, where the chipmunks may actually be considered an aid to reproduction. The competition in growth between the seedlings in these clumps becomes very keen early in their lives and they thin out rapidly, though it is not unusual to find ten or a dozen seedlings four feet high growing from a single hole. One unusual instance was noted where 29 fourteen-year-old saplings were living in a cluster. One-year-old seedlings in these chipmunk-sown clumps have been found to be less likely to succumb to drought than solitary seedlings, perhaps because they give each other protection.

It is not infrequent to find a dense row of seedlings, a veritable natural hedge from 25 to 75 feet long, located in the path of mineral soil and ashes left after a fallen tree had burned up. The cause of these hedges is not perfectly understood.

DEVELOPMENT OF SEEDLINGS.

Although seedlings start with considerable vigor after each good seed year, their mortality during the first year is exceedingly high. In the early summer the forest floor is sometimes thickly dotted with freshly sprouted seedlings, while on the same area the next year, as a consequence of the summer drought and the winter ground heaving, there will be but an occasional living seedling. A count of the seedlings on 67 small sample plots distributed over five acres, in the fall of 1910 (after the excellent seed crop of 1909 and the very dry season of 1910), showed that 79 per cent of the seedlings which started that spring had died by fall.[1] Probably not one seed in ten escapes the birds and rodents; and, of those that do germinate, probably as many are killed by late frosts immediately after germinating or by frost-heaving the first winter or by drought the first summer. It is estimated that in eastern Oregon hardly more than one seedling in a hundred lives to be 2 years old. After the first year the mortality from drought is very slight.

The year-old seedlings seem to do best beneath the partial shade of the mother trees, probably because of the protection which they are afforded against drying sun and winds, and perhaps against frost as well. Older seedlings do not do well in dry places directly beneath old trees, because of the absorption by the roots of the latter of all the available soil moisture; the seedlings that ultimately succeed are those in the gaps between the clumps of old trees or beneath those which have recently died. For some reason those in the latter situation are particularly flourishing in eastern Oregon. On dry soils, clumps of brush and mats of squaw-carpet (*Ceanothus prostratus*) seem to assist yellow-pine reproduction, probably by their effect in conserving the soil moisture.

For these reasons and for other causes which are not thoroughly understood, yellow-pine reproduction is extremely patchy in the virgin forest; here there will be almost a thicket of young trees, and near by, under seemingly similar conditions, there will be little or no reproduction.

In dry situations bordering the limit of yellow-pine growth, the reproduction seems to be greatly benefited by the protection that bushes afford, and it is conspicuously more abundant on the sheltered north side of clumps of bushes than elsewhere. An examination [2] of an area adjoining the desert in Crook County showed the following interesting results: Of all the yellow-pine seedlings 70 per cent were on the north side of sagebrush and bitterbrush bushes, 13 per cent

[1] Manuscript report, "Western Yellow Pine Reproduction," by George A. Bright, forest assistant.

[2] Manuscript report by Forest Supervisor M. L. Merritt, "Occurrence of Western Yellow Pine Seedlings in Openings in the Edge of the Deschutes National Forest, Bordering on the Desert."

A CLUMP OF WESTERN YELLOW-PINE SEEDLINGS ABOUT 6 YEARS OLD, GROWING FROM A CHIPMUNK'S STORE OF SEEDS.

were on the south side of these bushes, 11 per cent were sheltered by logs or lodgepole pines, and only 6 per cent were in the open, although these open spots occupied a considerable proportion of the area.

In the Blue Mountains the reproduction of yellow pine is very abundant, both in the virgin forest and after cuttings. Perhaps it is more prolific here than anywhere else. In this region where an area has not been burned over by a surface fire for a number of years, there is quite commonly a veritable thicket of little trees from a few inches to several feet high. Actual counts have shown that there are sometimes 14,000 seedlings on a single acre, the ages ranging from 13 to 21 years.

The first season most of the growth of the seedling is below ground; it forms a top only 2 or 3 inches high with a small tuft of short needles, but it grows a taproot from 7 to 12 inches long in its effort to reach subsoil moisture. The second year more of a top is formed, but growth is slow for at least four years, and does not become rapid in any event until the seedling has abundant light.

Table 3 gives an idea of the rate of growth of the dominant seedlings in average yellow-pine forests in the Blue Mountains, which is closely similar to the average growth of seedlings in other forests of central and eastern Oregon. In making this table only seedlings which had free growing space and looked as though they would live at least to the pole stage were included. The growth of even these dominant seedlings is exceedingly slow during their first 20 or 30 years.

TABLE 3.—*Seedling height growth, Blue Mountains, Oreg.*

[Based on 1,182 measurements.]

Age.	Height.	Age.	Height.	Age.	Height.
Years.	*Feet.*	*Years.*	*Feet.*	*Years.*	*Feet.*
1	0.2	5	0.8	9	1.5
2	.3	6	1.0	10	1.7
3	.5	7	1.1	15	2.7
4	.6	8	1.3	20	4.0

EFFECT OF FIRES.

Western yellow pine is classed commonly as a fire-resistant species, probably because in its open stands destructive crown fires are rare; but it is by no means immune to damage by fire. Occasionally a fire gets into the tops of the trees in a pure yellow-pine forest on a slope and sweeps over the whole hillside, perhaps a square mile in extent, killing all the trees in its path. This spectacular form of fire damage is uncommon, however; by far the greatest amount of damage is done by surface fires which work in an inconspicuous way. Light, slowly

spreading fires that form a blaze not more than 2 or 3 feet high and that burn chiefly the dry grass, needles, and underbrush start freely in yellow-pine forests, because for several months each summer the surface litter is dry enough to burn readily. Practically every acre of virgin yellow-pine timberland in central and eastern Oregon has been run over by fire during the lifetime of the present forest, and much of it has been repeatedly scourged.

It is sometimes supposed that these light surface fires, which have in the past run through the yellow-pine forests periodically, do no damage to the timber, but that they "protect" it from possible severe conflagrations by burning up the surface débris before it accumulates. This is a mistake. These repeated fires, no matter how light, do in the aggregate an enormous amount of damage to yellow-pine forests, not alone to the on-coming young trees, but to the present mature merchantable timber. This damage may be classified under several headings:

(1) The fire-scarring of the butts of merchantable yellow pine.

The bark of yellow pine in this region is not particularly thick at the base, and surface fires find no difficulty in eating through it and getting at the inflammable wood of the butt. A careful cruise of every tree on 154½ sample acres in typical yellow-pine stands in several localities in the Blue Mountains showed that 42 out of every 100 trees were fire-scarred—i. e., the wood was exposed because the bark had been burned off. Their susceptibility to fires is aggravated by the work of the red turpentine beetle (*Dendroctonus valens*), which, by working in the cambium at the base of the tree, loosens patches of bark and stimulates the flow of pitch. These fire-scarred trees may easily fall a prey to the next fire that runs through the forest, and some of them are so deeply scarred at the base that they are likely to be windthrown. It is noticeable that especially the larger (and therefore the older) trees are fire-scarred, because they have been exposed to more of these periodic fires. A record of 1,184 representative trees cut in a logging operation in Grant County shows that 22.8 per cent of the butt logs were fire-scarred (still more of the trees may of course have had scars which did not show on the log because the stumps were cut high enough to avoid them), and that 18.6 per cent of the butt logs were so badly fire-scarred that about 46.1 board feet per log (equivalent to 14 per cent of the full scale of the defective logs) was lost and had to be deducted from the full scale.

(2) The killing of occasional trees by the burning through of the base.

Though these surface fires kill very few trees outright by tne intensity of their heat, yet each fire—even the lightest grass fire—is apt to cause the death of a yellow-pine tree here and there by gnaw-

ing it off at the base with a smoldering flame. An examination of a great many burns in eastern Oregon shows that an average surface fire, on land which has been periodically burned over before, kills in this way one merchantable tree on from 1 to 4 acres. The average number on 130 sample acres examined in detail was one tree to every 1.12 acres. This is not a large number of trees, and they are so scattered about in a burn as not to be conspicuous; but in the aggregate it is an enormous loss, especially as each of the repeated fires may kill the same number, and the trees felled by these surface fires are usually the larger ones.

(3) The "pitching" of the butts of commercial trees.

Trees that are fire-scarred or which have been excessively heated about their bases are very apt to become "pitch-butted;" i. e., a great deal of "fat" pitch is deposited in the wood in the lower part of the stem. This pitch greatly lessens the value of the log for lumber because excessive pitch is a defect which bars lumber from the best grades on the market. A tally of 1,184 butt logs in the Blue Mountains shows that 25 per cent of them are "pitched" and that the average diameter of the pitchy area on the basal cross section of the log is 14.7 inches. This indirect result of surface fires is not conspicuous, but is a very real source of loss.

(4) The impoverishment of the soil by repeated burnings.

Frequent fires consume the vegetable matter, which should be allowed to accumulate and decay and thereby better the physical condition and add to the fertility of the soil.

(5) Destruction of the reproduction which should form the basis for the next crop.

Each fire kills the seedlings and some of the saplings, so that, if the fires are of frequent occurrence, no young growth has a chance to replace the mature trees that die from natural causes. Yellow pine normally occurs in Oregon in uneven-aged stands in which trees of all ages are in intimate mixture; frequent fires prevent the stand from having the proper number of young trees. If this process is continued long enough, it will annihilate the yellow pine by gradually killing off the old trees and at the same time preventing the survival and maturity of any young ones. This very thing has happened in places in the Siskiyou Mountains and southern Cascades. Here areas once covered by fine stands of yellow-pine timber are now treeless wastes, covered only by brush or mock chaparral.

(6) Degeneration in the forest type.

In certain parts of the State repeated surface fires have the effect of transforming the forest type from a stand consisting largely of yellow pine to one consisting of lodgepole pine, whose reproduction is extremely abundant and vigorous after fire.

Table 4 shows strikingly the damage that ordinary surface fires have done to the yellow-pine timber in several instances in various parts of Oregon:

TABLE 4.—*Damage done by surface fires to merchantable yellow pine over 12 inches in diameter.*

[Average of 156 sample acres distributed over four typical fresh burns in Oregon.]

Locality.	Percentage by number of trees in each class.			Apparently uninjured.
	Burned to death.	Felled by fire.[1]	Scarred by fire.[2]	
Lava Butte fire, 1911, Deschutes National Forest	3.2	0.8	31.9	64.1
Medical Springs fire, 1910, Minam National Forest	[3]	6.8	43.2	50.0
Big Minam River fire, 1910, Wallowa National Forest	[3]	3.2	46.9	49.9
Devil's Run fire, 1910, Wallowa National Forest	2.7	2.3	45.5	49.5

[1] The figures in this column would be fully twice as large if the percentage by volume of the trees that were killed, instead of the number, were taken, since it is chiefly the larger trees that are felled by fire.

[2] This column includes also trees that were scarred by previous fires, since it is impossible to distinguish those scarred in the last fire from those previously injured.

[3] On these burns the trees which were actually killed by the intense heat of the fire were not distinguished fr om those killed by being felled by the fire eating out basal fire scars.

SOURCES OF INJURY OTHER THAN FIRE.

INSECTS.[1]

Next to fire, insects are the most destructive enemies of yellow pine. Hardly a square mile can be found in the State in which there is not fresh evidence of insect damage to the living timber. There are many insects, chiefly boring grubs, that work in dead or dying yellow-pine trees and in yellow-pine lumber, but relatively few that attack the living tree. In Oregon there are but three species important enough to interest the forester and timberland owner; one of them is a defoliator and the others are bark beetles. The defoliator is the "pine butterfly" (*Neophasia menapia*), a small white moth, which, when in the caterpillar form (the caterpillars are black, with bright green markings, and are about 1½ inches long at maturity), feeds upon the needles of yellow pine. Sometimes the foliage on a tree is almost all eaten off and the tree suffers severe damage or, if the defoliation is repeated, death. This insect is found to some extent in various parts of Oregon, but so far as known it is not now doing any great amount of damage. There have been a number of serious infestations of the insect elsewhere, notably in Yakima and Chelan Counties, Washington, where yellow-pine timber over a considerable area was killed. It is a pest which is decidedly dangerous when it becomes abundant.

There are a large number of species of bark beetles which are more or less harmful to living yellow pine, but only two of them are particularly important in Oregon, the western pine destroyer (*Dendroc-*

[1] See Department of Agriculture, Bureau of Entomology, Bulletins 32; 38, pt. 2; and 83, pt. 1; and Circulars 125, 126, 127, and 129, for full description of these insects.

tonus brevicomis) and the mountain pine beetle (*Dendroctonus monticolæ*). These insects kill the trees which they infest by eating the soft inner bark and cambial layers, thereby girdling the tree. Colonies of the former are found here and there scattered through the yellow-pine region. Each colony kills a tree or two each year, but ordinarily shows no tendency to spread. A group of infested trees is usually characterized by from three to ten or more dead trees in a clump, some of which have apparently been dead several years, some a shorter period; and if the colony is still at work, by one or two reddish-topped trees. The bark of some of the trees commonly shows holes where woodpeckers have worked to get at the insects.

The inordinate multiplication of the insects is prevented by their natural enemies, so that usually they are found only in what may be called the normal infestation. Under exceptionally favorable conditions, possibly climatic, or as a result of a decrease in the number of their enemies, these insects may become at any time manyfold more plentiful; and if they do, they may kill an enormous amount of timber. They work chiefly in large, old trees, most frequently those which have been damaged by fire, by lightning, or otherwise. The damage that they do is inconspicuous because it is scattered, but in the aggregate it amounts to a great deal.

The mountain pine beetle has shown itself to be the worst insect enemy of yellow pine in Oregon. Colonies occur in greater or less abundance in the forests of the whole eastern part of the State, usually working in lodgepole pine. Recently it has been spreading with alarming rapidity through the lodgepole-pine forests on the upper slopes of the Blue Mountains, particularly on the Wallowa and Powder River Mountains, so that within the past few years 500,000 to 600,000 acres in these mountains have been attacked and more than half the lodgepole-pine trees on at least 300,000 acres have already been killed. Four or five years ago the insects extended their ravages to the yellow pine adjacent to the infested lodgepole pine and a good deal of it was killed. Had the infestation continued to spread in the yellow-pine timber as it began, the damage would have been enormous, but within the last two years it has subsided very greatly, evidently having been regulated in time by natural causes. These infestations evidently have their ups and downs and through some natural agency, imperfectly understood, subside and regain their normal balance. This bark beetle prefers to work in the smaller yellow pines, but at times attacks the largest and thriftiest old trees. Extensive operations in felling and barking infested trees have been conducted by the Forest Service and by individual owners in the Blue Mountains under the direction of the Bureau of Entomology, with the purpose of checking the spread of this pest; but definite conclusions as to the effectiveness of this work have not yet been reached.

VEGETABLE PARASITES.

The most harmful of the vegetable parasites is a kind of mistletoe (*Razoumofskya campylopoda*) which is, in some localities, very abundant. This plant attaches itself to the little twigs and causes in them, as they develop, swellings and deformities ("witches' broom"), both on the main stem and the twigs. It kills single branches outright, but seldom causes the death of a tree; it may, however, weaken the tree's vitality and impair its value for commercial purposes. A rust called *Peridermium filamentosum* causes, on the twigs, swellings which are quite conspicuous in yellow-pine young growth. Yellow pines, especially in the Blue Mountain region, as well as some of their associates, are often heavily covered with two lichens—*Alectoria fremontii*, "black moss," and *Evernia vulpina*. These plants are not fatal, but may injure the host trees by shading their foliage and preventing proper bark shedding and aeration.

Yellow pine is rather free from fungi which cause decay in the wood. One of its worst enemies among the fungi is *Polyporus schweinitzii* (butt rot or dry brown rot), which gains entrance through basal scars and damages particularly the lower portion of the tree. It is, like most forms of decay, a disease which affects old, overmature timber, and seems to be particularly abundant on situations where the soil is sterile or thin. It is usually difficult to tell from the outside appearance of a tree whether it is affected with butt rot. Another bad form of decay is *Trametes pini* (ring-scale fungus, pipe rot, or white-pitted rot), which enters the tree at broken tops or in bad wounds on the stem and rots out the heartwood. The presence of *Trametes pini* can usually be detected by the thin, unhealthy bark and the "bumpy" stems of seriously affected trees. *Fomes laricis* (chalky quinine fungus, or sap rot) is a third serious fungous enemy of yellow pine. It causes a red heart rot with felts of white mycelium.[1] Its fruiting bodies are generally very large, round, hoof-shaped, with a rough white, chalky surface.

The amount of decay in yellow-pine timber caused by these fungi is of course very variable; some thrifty stands are almost free from it, and in others it is very bad. On one tract of very overmature timber in central Oregon a third of the trees had to be long-butted from 4 to 6 feet each to get rid of the worthless portion of the first log. The scale of over 2,000,000 feet of logs cut in the Blue Mountains shows that only 0.9 per cent had to be subtracted from the full scale on account of rot. In addition, some worthless trees or portions of trees were left in the woods. This would probably indicate for this particular tract an amount of defect on account of rot equivalent to about 2 per cent of the total stand.

[1] U. S. Department of Agriculture, Forest Service Bulletin (unnumbered), "Forest-tree Diseases Common in California and Nevada," by E. P. Meinecke.

As is the case with other pines, freshly cut logs and lumber are apt to "blue" if not kept under water or dried soon after cutting; and the blue stain decidedly lessens their commercial value. The stain is caused by *Ceratostomella pilifera*[1] and other fungi.

THE ELEMENTS.

Yellow pine grows in a climate in which it is especially exposed to high winds, drought, severe winters, frost heaving, and lightning. The fact that it is able to survive as well as it does while other species can not is an indication that it is fairly immune to damage by these agencies.

It is, comparatively speaking, a windfirm species, and normally is able to stand without the protection of surrounding trees. Sometimes in the virgin forest a good many windfalls are found, but these are the result of an exceptionally high wind at a time when the trees were least able to withstand it, either because they were snow-laden or because the ground was wet. A recent storm in the Blue Mountains, such as is experienced in this region every year or two, blew down in a certain locality one tree to each 5 acres. The tornado of 1894 mowed down all the timber in its path for a mile or more, the yellow pines succumbing to its force as well as all other trees. Where a part of the stand has been removed by cuttings, the trees which are left are more liable to windthrow than they were in the virgin forest. On one tract of 1,624 acres in Grant County, 1,600 trees over 12 inches in diameter were thrown in the first two years after a partial cutting.[2] This is undoubtedly an exceptional instance, for similar areas of equal exposure have at the same time suffered merely a nominal amount of windthrow. In heavy winds no class of tree in partially cut-over areas seems to be entirely immune to windthrow, though the risk increases with the height of the tree and the density of its crown. Where the trees are in groups, the wind damage is considerably greater than where the reserved trees are evenly distributed. The effect of the winds is particularly severe in a solid body of uncut timber along the lee edge of a cut-over area.

Drought, of course, is a factor which limits the local distribution of this tree, for the yellow-pine forests in Oregon all abut on territory which is too dry for their growth. Drought seems to affect the reproduction chiefly, by preventing it from gaining a foothold on dry soils. After the sapling stage is passed, it is rarely killed by drought, though of course excessive drying of the soil affects the growth of the tree unfavorably.

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[1] "The 'Bluing' and 'Red Rot' of Western Yellow Pine," by Herman von Schrenk, Bull. 36, Bureau of Plant Industry, U. S. Dept. of Agriculture.

[2] Manuscript report, "Windfall Damage on Cut-over Areas," by R. E. Smith, forest examiner, and R. H. Weitknecht, assistant forest ranger.

Drought in combination with severe winter weather, particularly desiccating winds at a time when the ground is frozen after a dry autumn, sometimes does a good deal of damage to yellow pines in exposed situations. It occasionally happens that strips of timber adjoining the open country or in other particularly bleak and dry situations turn brown in the winter or early spring, all the old needles fall, and the trees are apparently winterkilled, but leaf out as usual after the growing season begins. To this form of injury the name "red-belt disease" has been given. Yellow pine does not suffer any more than its associates, and possibly less than Douglas fir. In the winter of 1909 the foliage on several thousands of acres in Morrow County (and to a less extent in Crook and Grant Counties), chiefly on the north slopes adjoining the open country, turned brown, and the trees were apparently winterkilled, but recovered and seem to be in no way permanently injured.

"Spike-top," or "stag-headedness," is commonly an indirect result of drought, and is usually an accompaniment of old age. In the virgin stands of yellow pine in Oregon, as elsewhere in this tree's range, there is a good deal of this defect, often from 10 to 15 per cent of the merchantable trees being affected. This is natural, since in the primeval forest such a large proportion of the trees are very old and past maturity. "Spike-top" considerably reduces a tree's value, both because the dead tip of the tree is worthless and because it is an entering place for decay.

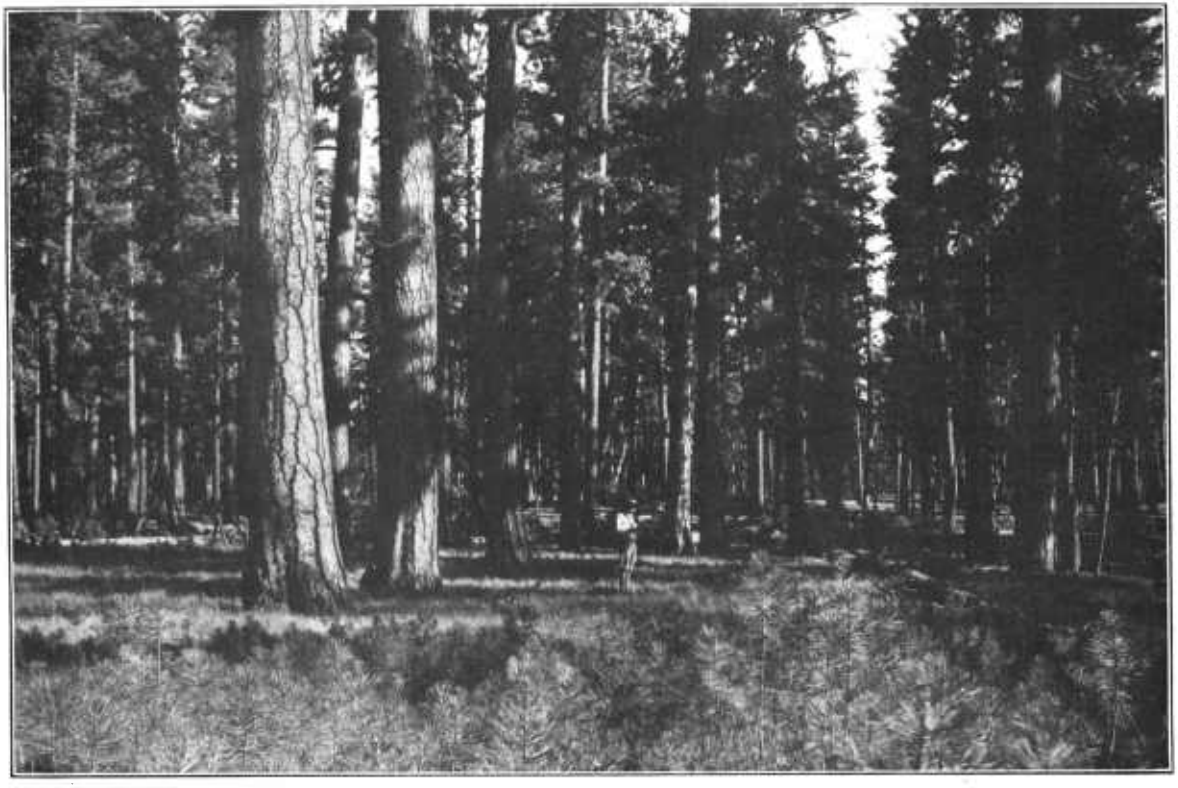
In certain regions, particularly on the pumice soils of central Oregon, the soil in the forest "heaves" in the spring and autumn and lifts young seedlings out of the ground. This occurs here to such an extent as to make it difficult for reproduction (either natural or planted seedlings) to get a good start; some of the seedlings are killed outright, and many do not recover for years from the root injuries which they receive when young.

Thunder storms are not infrequent in the Cascade and Blue Mountain regions of Oregon, and often yellow pines are struck by lightning. They are then scarred in such a way as to detract from their commercial value and occasionally are shattered or killed outright. It is not unusual for a group of half a dozen trees to be struck at the same time, so that the ground over half an acre is littered with chunks of bark and splinters.

ANIMAL LIFE.

Yellow pine suffers comparatively little injury from animals. Porcupines and other rodents gnaw the bark of saplings and small poles, and occasionally seriously damage or kill them. Sapsuckers and woodpeckers seem to confine their activities chiefly to dead and insect-infested trees of this species and do no damage to the wood; in fact, they undoubtedly do a great deal of good by destroying harmful insects.

LARGE WESTERN YELLOW PINE, BADLY SCARRED AT BASE AS A RESULT OF REPEATED LIGHT SURFACE FIRES, KLAMATH COUNTY, OREG.



EXCELLENT STAND OF WESTERN YELLOW PINE IN GRANT COUNTY, OREG.

Showing the variety in size and age of the trees, the openness of the forest, the plentiful herbage beneath the trees, and the abundance of seedlings in groups, characteristic of Blue Mountain timber.

Since yellow-pine forests are grazed over by sheep and cattle, the reproduction is somewhat exposed to damage by these animals, particularly by sheep, which trample a good many seedlings when close herded. Sheep also, when short of forage, as along driveways or near bed grounds, browse on them in such a way as to deform the seedlings permanently. If the range is not overstocked and the sheep are properly handled, they will not, in Oregon, do any appreciable damage to the yellow-pine young growth in the forest at large; trees over 6 feet high are practically immune from damage.

In some parts of the State, particularly in Klamath County, are found here and there large trees upon which are great scars, from 3 to 7 feet above the ground, half encircling the tree. (See Pl. III.) These scars were caused years ago by Indians who, in the springtime, stripped the bark in order to get at the mucilaginous layer of forming wood, which they scraped off and used as food.[1] The scars make the trees vulnerable to light surface fires and detract considerably from their merchantable value.

CHARACTER OF THE STANDS.

Yellow pine is fundamentally a gregarious tree; that is, it is a tree which does best and is found most commonly in pure or nearly pure stands. Most of the forests of Oregon in which it occurs commercially are at least 75 per cent yellow pine, and the other trees that are present in the mixture are apt to grow in groups by themselves and not in intimate mixture with the pine. One reason why yellow pine occurs so largely in pure stands is that it will grow and form fine forests in situations on the plateaus and south slopes that are too dry and hot for other species, and being a rather unsuccessful competitor of the more tolerant species, Douglas fir, white fir, and lodgepole pine, it is largely excluded from soils moist enough for these species to thrive in. It does occur, however, in mixture with other species in almost every degree.

In most of the pure yellow-pine forests of the State the trees are spaced rather widely, the ground is fairly free from underbrush and débris, and travel through them on foot or horseback is interrupted only by occasional patches of saplings and fallen trees. (See Pl. IV.) The forests are usually not solid and continuous for great distances, except along the eastern base of the Cascades, but are broken by treeless "scab-rock ridges," or natural meadows. On the north slopes, in draws, or in other places where mixed with other species, the yellow-pine forests are usually denser, more brushy, and therefore harder to traverse. Toward the limits of the forests adjoining the desert the stand is confined usually to a fringe of trees along the

[1] Sargent's Silva, XI, p. 82.

canyon sides, to draws, and to the north hillsides, the intervening drier and more exposed areas being treeless. Instances are seen here and there where an advance guard of young yellow pines is progressing from the forest into the desert, indicating that the limits of the yellow-pine forest are being extended in places. Bordering the desert it is often in mixture with western juniper (*Juniperus occidentalis*). At the upper altitudinal limit of its distribution the typical yellow-pine forest gives way rather suddenly to a very different, much denser stand of other species.

ASSOCIATES.

The associates of yellow pine in mixed stands are variable, and depend upon the locality. In the Blue Mountains western larch (*Larix occidentalis*) is its usual companion and grows with it in an intimate and harmonious mixture. In the moister situations white fir (*Abies concolor*) is a common associate, as is also Douglas fir (*Pseudotsuga taxifolia*) in most parts of the State. All of these species occur to a large extent in groups by themselves; in the Blue Mountains it is common for the south slopes to be covered with a fine stand of yellow pine, while the north slopes are covered almost entirely with larch, white fir, and Douglas fir. Lodgepole pine (*Pinus contorta*) is another common member of the mixed forests, particularly along the eastern slopes of the Cascades. It is a thrifty and militant species, and has the ability to occupy burns to the exclusion of all others. With the help of periodic surface fires, which have encouraged its reproduction and at the same time discouraged the reproduction of yellow pine, it has been able to encroach upon land where yellow pine might be growing.

On the southern Cascade and Siskiyou Mountains (Klamath, Jackson, and Josephine Counties) the forest is different from that in the drier parts of the State. In these two ranges the yellow pine is intimately mixed with sugar pine, Douglas fir, white fir, and incense cedar, and occurs in the largest proportion on southerly exposures. On the cooler, moister situations it gives way to heavy stands of Douglas fir. Here there is ordinarily a great deal of underbrush and chaparral, and the more open the woods the greater the amount of brush. In this region its usual mature size is larger than in the other parts of the State.

DISTRIBUTION OF AGE CLASSES.

Yellow pine grows commonly in many-aged stands; i. e., trees of all ages from seedlings to 500-year-old veterans, with every age gradation between, are found in intimate mixture. In some stands there is a preponderance of very old trees; in fact, in many of the virgin stands of central and eastern Oregon there are more of the very old trees and less of the younger than the ideal forest should contain. Usually two or three or more trees of a certain age are found in a

small group by themselves, the reason being that a group of many young trees usually starts in the gap which a large one makes when it dies. In the virgin stands throughout the State there seems to be a very large proportion of trees whose age is about 225 or 275 years, suggesting that after this age their mortality is greater.

Table 5 shows the uneven age of an average yellow-pine stand. It is an enumeration of the trees of each age on a logged-over tract near Embody, Lake County, the rings on the stumps of practically all the sound merchantable trees being counted.

TABLE 5.—*Number of trees of each age by decades on a representative 40-acre tract near Embody, Oreg., only trees (cut in a clean-cutting logging operation) whose annual rings could be counted being taken.*

Age.	Number of trees.	Age.	Number of trees.	Age.	Number of trees.	Age.	Number of trees.
100	4	190	22	280	15	370	3
110	2	200	19	290	9	380	1
120	13	210	8	300	7	390	1
130	8	220	13	310	11	400	5
140	14	230	17	320	8	410	2
150	31	240	28	330	13	420	2
160	16	250	21	340	10	430	1
170	21	260	13	350	6	440	6
180	20	270	10	360	2	450	17

NUMBER OF TREES PER ACRE.

Table 6 shows the average space in square feet controlled by trees of various sizes in a representative stand of pure yellow pine in central Oregon.[1]

TABLE 6.—*Space available to average trees of various sizes in pure yellow-pine forests. Basis, 45 trees.*

[Data taken near Mill Creek, Crook County.]

Diameter class.	Space available to each tree.	Diameter class.	Space available to each tree.
Inches.	*Square feet.*	*Inches.*	*Square feet.*
16	1,031	26	1,022
18	944	28	1,307
20	1,122	30	1,405
22	1,225	32	1,366
24	1,235	34	1,947

By this table it is seen that each tree 16 inches in diameter occupies in the virgin forest 1,031 square feet, allowing thereby only a possible 42 trees per acre; if they averaged 30 inches in diameter and required 1,405 square feet, there would be space for but 31 trees. But there are usually so many gaps in the yellow-pine forest that there are considerably less than this possible theoretic number of trees. The difference between the yellow-pine and the Douglas-fir forests is

[1] The area controlled by each tree is considered to be the irregular polygon about the tree whose corners are at half the distance to each neighboring tree's base.

striking. In forests of Douglas fir in western Oregon there are commonly as many as 167 trees per acre, when the diameter of the average tree is 16 inches, and 88 trees when the average is 26 inches.[1]

In pure, fully stocked stands in the Blue Mountain region there are commonly from 20 to 30 yellow pines per acre over 12 inches in diameter, of which but few are over 30 inches. Over large areas the average number per acre is ordinarily less than 20. On the slopes of the Cascades the number of trees per acre averages somewhat less than in the Blue Mountains, but the trees are larger. In mixed stands the number of yellow pines of merchantable size is naturally less, though the total number of trees of all species is as a rule larger, the moist soil on which the mixed forest grows being able to carry a denser stand.

Table 7 gives an indication of the average number of trees per acre and the distribution of their diameter classes in representative stands in various parts of the State; it is based on the measurement of several large sample plots in each locality. It does not attempt to show the comparative density or size of the timber or the mixture of species in the several regions, but merely shows by samples the variability of Oregon's normally stocked virgin forests.

TABLE 7.—*Number of trees per acre by diameter classes of yellow pine and of other species in several representative stands in central and eastern Oregon.*

Diameter at breastheight.	Near Austin and Whitney, Grant and Baker Counties. Basis: 258½ acres.		Near Lookingglass Creek, Union County. Basis: 44 acres.		Near Winlock's Mill, Wheeler County. Basis: 20 acres.
	Yellow pine.	Others.	Yellow pine.	Others.	Yellow pine.
Inches.					
2	3.70	4.30	4.00	4.00	.....
4	2.46	3.44	3.00	3.00	11.45
6	2.22	2.58	3.11	3.55	11.45
8	2.29	1.41	5.02	1.41	4.50
10	1.90	1.04	5.11	1.39	2.55
12	2.01	.94	5.27	1.09	2.85
14	2.23	.86	4.53	1.07	2.80
16	2.21	.59	3.43	.59	1.70
18	2.54	.69	3.34	.45	1.35
20	2.65	.53	2.52	.57	1.40
22	2.50	.53	2.86	.48	1.50
24	2.45	.41	2.75	.29	1.65
26	2.26	.32	2.68	.32	1.25
28	1.99	.22	2.07	.09	.95
30	1.41	.20	1.41	.09	.55
32	1.15	.14	1.21	.07	.25
34	.80	.06	.68	.09	.30
36	.52	.08	.80	.11	.10
38	.37	.07	.25	.09	.....
40	.16	.01	.36	.....	.....
42	.08	.02	.14	.....	.....
Over 43	.09	.03	.27	.....	.....
Total	38.00	18.47	54.81	18.75	46.60
Total over 12 inches	25.42	5.70	34.57	5.40	16.65

[1] Forest Service Circular 175, "Growth and Management of Douglas Fir in the Pacific Northwest," by Thornton T. Munger.

TABLE 7.—*Number of trees per acre by diameter classes of yellow pine and of other species in several representative stands in central and eastern Oregon*—Continued.

Diameter at breastheight.	Near Embody, Lake County. Basis: 30 acres.		Near Lapine, Crook County. Basis: 40 acres.	Klamath Lake Region, Klamath County. Basis: 159 acres.	
	Yellow pine.	Others.	Yellow pine.	Yellow pine.	Others.
Inches.					
2	14.11	0.08	0.75	6.71	8.52
4	9.41	.07	.50	5.23	5.29
6	4.71	.05	.25	2.72	5.28
8	4.73	.13	.32	2.09	2.46
10	4.33	.17	.22	1.94	1.29
12	3.27	.06	.25	1.79	1.35
14	3.83	.06	.35	1.84	1.06
16	3.67	.....	.25	1.99	1.21
18	3.30	.06	.42	2.09	.67
20	2.83	.....	.65	2.35	1.14
22	2.80	.....	1.00	1.96	.45
24	2.23	.03	1.10	2.27	.72
26	2.20	.....	1.15	1.99	.62
28	1.70	.....	1.22	2.46	.48
30	1.47	.....	1.40	1.74	.45
32	1.33	.....	1.32	1.35	.44
34	1.30	.....	.67	1.10	.36
36	.80	.....	.80	.72	.24
38	.37	.....	.60	.59	.16
40	.20	.....	.42	.38	.15
42	.30	.....	.....	.30	.08
Over 43	.40	.....	.27	.45	.26
Total	69.29	.71	13.91	44.06	32.68
Total over 12 inches	32.00	.21	11.87	25.37	9.84

VOLUME PER ACRE.

Yellow-pine forests are so irregular in density that figures for the average stand per acre or per quarter section are apt to be misleading. Though the volume of timber may be very high on an area of an acre or so, there are usually openings in the forest, groups of young growth, glades, or barren spots, which reduce the average per acre volume of any large tract. Single sample acres frequently have a stand of 50,000 feet b. m. both in the Blue Mountain region and on the Cascades, but it is considered to be a good quarter section that has 4,000,000 feet b. m. or 25,000 feet to the acre. The following estimates of the amount of merchantable timber on two small watersheds, in different parts of the State, are representative of the regions which they typify, and illustrate the average density and composition of species on large tracts such as are now being logged. Estimate A is for a watershed at the head of one branch of the John Day River in the Blue Mountains, and Estimate B is for a watershed on the eastern slopes of the Cascades in Klamath County.

Estimate A.

Total area of watershed	acres..	11,777
Area covered by merchantable timber [1]	do....	6,297
Average stand per acre, of all species, on area of merchantable timber	feet b.m..	13,672
Total stand composed of—		
Western yellow pine	per cent..	84
Western larch	do....	9
Douglas fir, white fir, and lodgepole pine	do....	7

[1] The balance of the watershed is meadow, barren "scabby" ridges, patches of young timber, and noncommercial stands of lodgepole pine.

Estimate B.

Total area of tract	acres	7,120
Area covered by merchantable timber [1]	do	6,503
Average stand per acre, of all species, on area of merchantable timber, feet b. m.		18,683
Total stand composed of—		
Western yellow pine	per cent	64
Douglas fir	do	21
White and Shasta firs	do	12
Sugar and white pine	do	2
Lodgepole pine, Engelmann spruce, and incense cedar	do	1

LOG GRADES.

Tracts of timberland in various parts of the State are very variable in the quantity of timber that they carry; and there is just as much variance in the quality. In cruising the timber on a tract for purposes of sale, it is customary to estimate the amount of the upper grades that the tract will yield. Good yellow-pine timberland will yield 50 per cent of "No. 2 Shop" lumber or better.

It would be desirable to have in general use a scheme for grading yellow-pine logs in the standing forest, similar to that used by the Forest Service in its cruises, or similar to that used in marketing rafts of Douglas-fir logs on the coast, so that the yield of a tract could be expressed in terms of the amount of No. 1, No. 2, and No. 3 logs, or clear, shop, and common logs. The specifications for such log grades proposed by the Forest Service and in use in Government cruises in Oregon are as follows:

No. 1 logs shall be 22 inches or over in diameter inside the bark at the small end and not less than 10 feet long. They shall be reasonably straight-grained, practically surface clear, and, in the judgment of the scaler, capable of cutting not less than 25 per cent of their scaled contents into lumber of the grades of C select and better (including Factory C).

No. 2 logs shall be 18 inches or over in diameter inside the bark at the small end, not less than 8 feet long, and, in the judgment of the scaler, capable of cutting not less than 30 per cent of their scaled contents into lumber of the grades of No. 2 shop and better (including No. 1 common).

No. 3 logs shall be 6 inches or over in diameter inside the bark at the small end and not less than 8 feet long, having defects which, in the judgment of the scaler, prevent their classification into either of the above two grades.

Two mill-scale studies have recently been made in the Blue Mountain region to determine the amount of each grade of lumber obtainable from logs of each of the grades above described. One of the studies (labeled Test A) was made where the quality of the timber was exceptionally good and the other (labeled Test B) was made where it was poorer than the usual run. The results of both studies are presented in Table 8;[2] the average run of Blue Mountain yellow-pine timber would probably fall between the two extremes.

[1] The balance of the watershed is meadow, barren "scabby" ridges, patches of young timber, and noncommercial stands of lodgepole pine.

[2] From manuscript reports by Forest Examiner H. B. Oakleaf, dated November, 1913, and March, 1915.

TABLE 8.—*Quality of sound yellow-pine logs*[1] *in the Blue Mountain region of Oregon.*

Lumber grades.	Test A, good quality timber, log grades.				Test B, poor quality timber, log grades.			
	1	2	3	All.	1	2	3	All.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
B and better	18.8	3.0	0.2	8.1	17.4	4.3	1.5	3.7
C select	17.4	5.9	1.2	8.9	15.8	6.4	2.9	5.3
D select	8.0	3.8	2.5	5.0	8.4	5.5	4.3	5.1
No. 1 shop	13.6	15.9	4.2	11.8	10.8	12.1	2.6	7.2
No. 2 shop	14.3	28.5	14.8	19.3	14.6	21.4	10.3	15.3
No. 3 shop	7.2	9.8	12.6	9.6	4.9	5.9	5.3	5.6
No. 1 common	.8	2.8	4.5	2.5	2.2	6.9	18.6	12.5
No. 2 common	4.7	13.8	22.9	12.9	8.6	13.0	25.0	18.7
No. 3 common	10.9	13.8	31.0	17.6	14.4	20.1	23.9	21.7
No. 4 common	4.3	2.7	6.1	4.3	2.9	4.4	5.6	4.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Per cent of each log grade	39	35	26	100	8	44	48	100

[1] Green lumber. Depreciation in drying not provided for.

GROWTH.[1]

INDIVIDUAL TREES.

Because of the wide range of conditions under which it grows the rate of growth of yellow pine is exceedingly variable, perhaps rather more so than that of most species. In very favorable situations it grows so much each year that it would be classed as a rapid-growing species; in unfavorable situations it is exceedingly slow. In eastern and central Oregon its average rate of growth is somewhat more than in the southern Rocky Mountain region and the southwest, and decidedly more than in the Black Hills of Dakota.[2] The upper slopes of the Sierras in California is the region of most rapid growth. The growth there is probably about the same as on the Siskiyou Mountains and the west slope of the Cascade Mountains, the region of most rapid growth in Oregon. For the Siskiyou and Cascade regions, however, no specific growth data are available.

Broadly speaking, during its first 10 or 15 years yellow pine grows very slowly; then follows a period of 75 or 100 years in which both diameter and height growth are rapid, exceptionally thrifty trees making an increase of one-half inch in diameter and 2 feet in height in one year. By its one hundred and fiftieth year the height increment has fallen off very much, the tree has nearly reached its mature height, and thereafter grows but a foot or two each decade. Diameter growth also decreases after the first century of life, the rings become narrower and narrower with age, and on very old trees, or those that have been suppressed, they are so fine as to be hardly distinguishable except with a magnifying glass. It is usual, therefore, for the annual rings to be broad and well defined in young trees

[1] The tables and some of the other material in this chapter are taken from the manuscript report prepared by Mr. G. A. Bright, forest assistant, entitled "A Study of the Growth of Yellow Pine in Oregon," which embodies in detail the results of the field study of this species made by the Forest Service in 1910-11.

[2] Forest Service Circular 127, "Forest Tables—Western Yellow Pine."

and at the center of old ones, but narrow in the exterior rims of old trees, sometimes 90 to an inch of radius.

Yellow pine is a long-lived tree. The oldest encountered in the analysis of 4,997 stumps in eastern and central Oregon was in its six hundred and eighty-seventh year when cut for lumber.

DIAMETER AND HEIGHT GROWTH.

In Tables 9 and 10 the rate of growth of yellow pine, both in height and diameter, is given for a number of typical localities in the central and eastern parts of the State. These measurements are the result of detailed study and analysis by the Forest Service of 4,997 felled trees [1] in 20 different localities. The wide variation in the rate of growth in the several regions should not be interpreted to indicate necessarily the superiority of one region over another, but rather the effect of local variations in soil, exposure, or climate upon the rate of growth. In some regions of the State the data were taken in very favorable, well-watered situations, while in other regions it chanced that the data were collected in unfavorable situations.[2]

[1] In 1910 and 1911.

[2] In order that the growth in these several localities may be compared intelligently, the following brief description of the conditions on each is given:

1. Austin, Whitney, Grant, and Baker Counties: Practically pure stands on rather dry, rolling hills at altitudes of from 4,500 to 4,800 feet. Soil: Loamy, decomposed lava, not deep.

2. Lookingglass Creek, Union County: Stands with about 5 per cent of other species, growing in coves and on gentle slopes at an altitude of 3,200 feet. Climate: More humid than is usual at that elevation in the Blue Mountains. Soil: Good, deep, loamy, decomposed lava.

3. Parker's Mill, Morrow County: Pure yellow-pine stand near foot of gentle south slope. Altitude: 3,500 feet. Soil: Fairly deep, loamy, decomposed lava.

4. Winlock's Mill, Wheeler County: Pure yellow-pine stand on hot, dry, south slope. Altitude: About 3,300 feet. Soil: Fairly deep, loamy, decomposed lava, very dry in summer.

5. Ochoco Creek, Crook County: Pure yellow-pine stand on all slopes of rolling country, near lower altitudinal limits of forest. Altitude: About 3,000 feet. Soil: Loamy, decomposed lava, very dry in summer

6. Mill Creek, Crook County: Stands with 10 per cent or so of other species on a rolling plateau at altitude of 3,500 feet. Soil: Loamy, decomposed lava of good depth, not excessively dry.

7. Tamarack Creek, Wasco County: Stands averaging at least 10 per cent of other species, growing on steep slopes on both sides of the creek. The soil is loamy and the moisture conditions better than average

8. Metolius Creek, Crook County: Stands with about 5 per cent of other species on fairly level ground: where moisture conditions are good (for east of the Cascades) and the soil deep and loamy.

9. Sisters (1), Crook County: Pure stand of yellow pine on flat at altitude of about 3,000 feet. Soil: A loose, gravelly sand, nonretentive of moisture. Sisters (2) tract is very similar in every respect to the Sisters (1) tract.

10. Bend, Crook County: Pure stand of yellow pine on south slopes closely adjoining treeless desert at altitude of 3,700 feet. The soil is shallow and sandy.

11. Lapine (1) and (2), Crook County: Almost pure stands on a flat at altitude of about 4,200 feet. Soil a loose, sterile, coarse pumice, nonretentive of moisture. The location and physical condition on (1) and (2) are very similar.

12. Lapine (3), Crook County: Same as Lapine (1) and (2) except located on a lower bench, 15 feet above Deschutes River, so that it, doubtless, receives some helpful subirrigation.

13. Fort Klamath, Klamath County: Stands composed of 25 or 30 per cent of other species on flat at altitude of 4,100 feet. Soil: A fine, loose pumice. Climatically, moisture conditions are good.

14. Crystal Creek, Klamath County: Stand with about 30 per cent of other species on east slope at altitude of 4,200 feet. Soil: Rocky, loamy, decomposed lava. Moisture conditions are good.

15. Odessa, Klamath County: Stand averaging 85 per cent yellow pine on benches and gentle east slope. Altitude: About 4,200 feet. Soil: rocky, loamy, decomposed lava.

16. Meadow Lake, Klamath County: Stand about 90 per cent yellow pine on rolling hills at altitude of 4,500 feet. Soil: Loamy, decomposed lava, probably with some lime content.

17. Keno, Klamath County: Practically pure stand on low rolling hills at altitude of 4,200 feet. Soil: Loamy, decomposed lava; site rather dry in summer.

18. Embody, Lake County: Stand practically pure yellow pine on easterly slope at altitude of 5,000 feet. Climate: Rather dry and severe. Soil: Loamy, decomposed lava.

From these tables it is possible to determine what height and what diameter a yellow pine may be expected to reach in 50, 100, or 150 years under each of the several sets of conditions which each locality typifies. These data were of course collected in virgin forests. A comparison of the growth of the present young trees with the growth of the old trees when they were young, and of the growth of trees of various sizes, indicates that the young, thrifty trees now are growing at the same rate that their parent trees did when they were of the same age. It is fair to assume, therefore, that future growth in the natural forest will be at the same rate.

TABLE 9.—*Average total height of yellow-pine trees at various ages for 13 typical stands in several localities in Oregon.*

Locality.	Basis: Number of trees.	Age of trees in years.							
		50	100	150	200	250	300	350	400
		Total height in feet.							
Austin and Whitney, Grant and Baker Counties	437	22	58	86	100	110	115	117	119
Lookingglass Creek, Union County	588	38	79	104	115	119	121	122	123
Ochoco Creek, Crook County	187	19	54	79	93	101	104	106	107
Mill Creek, Crook County	224	29	66	88	107	118	124	126	129
Tamarack Creek, Wasco County	125	23	70	95	106	108	109	109	109
Metolius Creek, Crook County	36	25	65	95	113	124	129	130	130
Sisters, Crook County (1) and (2)	128	22	59	79	88	91	92	93	93
Bend, Crook County	66	21	54	82	90	91	92	.....	.....
Lapine, Crook County (1) and (2)	131	14	48	81	99	111	117	121	122
Lapine, Crook County (3)	57	24	64	90	105	116	122	125	126
Fort Klamath, Odessa, Meadow Lake, and Keno, Klamath County	460	29	69	92	106	114	118	121	124
Crystal Creek, Klamath County	86	23	65	120	139	146	149	150	150
Embody, Lake County	22	22	59	80	91	97	103	108	113
Total	2,547	.....	.....	.....	.....	.....	.....	.....	.....
Average	.....	24	62	90	104	111	115	119	120

TABLE 10.—*Average diameters of yellow-pine trees at various ages for 18 typical stands in several localities in Oregon.*

Locality.	Basis: Number of trees.	Age of trees in years.							
		50	100	150	200	250	300	350	400
		Diameter in inches outside bark at breastheight.							
Austin and Whitney, Grant and Baker Counties	672	4.0	10.8	15.7	19.4	22.2	24.4	26.5	28.4
Lookingglass Creek, Union County	409	6.6	14.1	19.4	22.7	25.5	29.0	32.7	34.1
Parker's Mill, Morrow County	245	3.0	10.2	15.8	20.2	24.2	27.8	30.8	33.4
Winlock's Mill, Wheeler County	407	2.5	9.9	15.2	19.0	22.7	26.4	30.0	33.0
Ochoco Creek, Crook County	474	4.4	12.3	18.2	22.1	25.2	27.8	29.7	30.7
Mill Creek, Crook County	405	4.1	11.6	17.6	22.0	25.6	28.4	30.6	32.4
Tamarack Creek, Wasco County	238	5.0	14.6	20.5	24.0	26.2	28.1	29.7	31.0
Metolius Creek, Crook County	66	4.4	13.1	19.1	23.6	27.1	30.0	32.2	33.8
Sisters, Crook County (1)	267	3.9	12.8	18.6	22.7	25.8	28.8	31.3	33.6
Bend, Crook County	183	4.7	15.4	20.7	24.4	27.3	29.9	.....	.....
Lapine, Crook County (1)	361	2.8	9.6	17.9	23.2	27.4	30.6	33.2	35.5
Lapine, Crook County (3)	91	3.4	11.5	20.2	26.0	29.9	32.8	35.1	36.7
Fort Klamath, Klamath County	110	5.9	17.1	24.3	28.2	31.2	33.8	36.3	38.5
Crystal Creek, Klamath County	87	10.6	22.2	28.5	33.1	37.0	40.7	.....	.....
Odessa, Klamath County	156	4.5	13.9	20.0	23.8	26.5	28.8	30.9	33.0
Meadow Lake, Klamath County	245	5.0	13.3	19.3	23.3	26.5	28.8	30.7	32.5
Keno, Klamath County	52	5.7	14.0	20.0	23.5	26.1	28.3	30.1	31.7
Embody, Lake County	400	3.5	10.5	16.1	20.1	23.1	25.5	27.8	29.9
Total	4,868	.....	.....	.....	.....	.....	.....	.....	.....
Average	.....	4.7	13.2	19.3	23.4	26.6	29.4	31.1	30.0

An analysis of these tables brings out some interesting points. Rapid diameter and rapid height growth are by no means associated always; a stand may make a very good diameter growth and yet poor height development, particularly in some of the open stands in the dry situations bordering the desert. Sustained growth rate seems also to depend upon the character of the situation. Apparently the rate is sustained longest on the poor sites where it is the lowest, as though the tree were striving to reach certain dimensions before its increment slackened.

The period of most rapid growth is reached early in the life of the tree. In all the 18 localities for which data are given above, the culmination of the annual growth in diameter takes place between the fortieth and the one hundred and fiftieth year, usually about the seventy-fifth year; in height growth, it takes place between the forty-third and ninety-seventh years, averaging about the sixty-fifth year. The culmination of the mean annual growth is of course later, and in these localities was found to be between the seventy-eighth and the one hundred and forty-fifth year (average 109 years) in the case of height growth, and between 80 and 190 years (average 120 years) in the case of diameter growth. While the data are not wholly consistent, both the mean and the annual diameter and height growth culminate latest on the poorest sites.

VOLUME GROWTH.

No specific volume growth measurements were taken in the field, but the volume growth tables have been derived from volume tables and the diameter and height growth data.

Table 11 indicates the average number of board feet in trees of various ages in several typical localities. It shows that in an unfavorable site, such as that near Winlocks Mill, the trees do not come to be of merchantable size (12 inches in diameter) until 140 years old, and that it takes 200 years for a tree to have a volume of 280 board feet, and 300 years for it to have 900 feet; while on a favorable site, such as at Fort Klamath, the average tree becomes merchantable in 80 years, and at 200 years contains 1,190 board feet. The culmination of the annual and mean annual volume growth takes place, as would be expected, later than that of the diameter and height growth. The period of most rapid current volume growth (which may be derived from Table 11) falls variously from the one hundred and fiftieth year to the limit of the table, while the maximum mean annual volume growth usually occurs outside the limits of the table, 500 years.

TABLE 11.—*Average merchantable volume in board feet of yellow-pine trees at various ages for 10 typical localities in Oregon.*

Age, years.	Whitney and Austin.	Lookingglass Creek.	Winlock's Mill.	Ochoco Creek.	Sisters (1).	Lapine (1).	Fort Klamath.	Odessa.	Meadow Lake.	Embody.	Average.[1]
	Volume of tree, in board feet.										
20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
60	.....	.....	.....	.....	.....	.....	.....	.....	20	.....	55
80	.....	.....	.....	.....	.....	.....	80	20	50	.....	92
100	50	150	.....	.....	20	.....	230	90	95	.....	140
120	150	260	20	70	105	.....	400	180	160	10	172
140	205	380	75	165	195	80	600	300	250	115	279
160	275	500	140	265	290	210	800	440	360	180	407
180	350	605	205	375	390	370	1,000	580	490	250	544
200	430	705	280	480	500	540	1,190	710	630	320	688
220	510	810	365	600	610	730	1,370	830	780	400	835
240	590	935	470	720	730	920	1,550	950	920	480	982
260	670	1,070	590	840	860	1,110	1,730	1,060	1,050	570	1,130
280	750	1,230	740	960	980	1,300	1,910	1,170	1,170	670	1,279
300	835	1,430	900	1,070	1,110	1,480	2,090	1,280	1,290	770	1,430
320	925	.....	1,090	1,170	1,240	1,660	2,260	1,380	1,400	880	1,431
340	1,020	.....	1,270	1,260	1,370	1,820	2,430	1,480	1,510	990	1,564
360	1,110	.....	.....	1,320	1,500	1,980	2,600	1,580	1,610	1,110	1,702
380	1,210	.....	.....	1,370	1,600	2,120	2,770	1,680	1,700	1,230	1,838
400	1,300	.....	.....	1,420	1,790	2,260	2,940	1,770	1,790	1,340	1,955
420	1,390	.....	.....	1,450	1,930	2,400	.....	.....	1,870	1,440	2,017
440	1,480	.....	.....	1,470	2,070	2,540	.....	.....	1,940	1,540	2,123
460	1,570	.....	.....	1,490	2,210	2,680	.....	.....	2,010	1,640	2,155
480	1,660	.....	.....	1,500	2,350	2,820	.....	.....	2,080	1,730	2,240
500	1,750	.....	.....	1,510	2,490	2,960	.....	.....	2,150	1,820	2,322

[1] The average of 20 separate stands in Oregon, the data for only 10 of which are given in the above table.

FACTORS AFFECTING GROWTH.

The most important single factor that affects growth is the amount of available soil moisture. Provided that climate and drainage are satisfactory, the most rapid growth is found in well-watered situations—in coves, on moist north and south slopes, and on benches. Heat also tends to promote the vigor of growth, provided soil and moisture conditions are satisfactory; hence at the higher, colder elevations and in cold situations growth is slower.

Another factor which materially affects the rate of growth of individual trees is the density of the stand. In the study of the crown space needed by trees of various sizes (see Table 6) it was found that trees make their maximum growth when they have more space than they do in the average virgin forest, open as it is. Beyond a certain point increase in available crown space apparently does not cause an increase in the growth rate. In some situations an excess of room seems to inhibit growth, perhaps because it subjects the tree to excessive exposure to wind and evaporation. It is natural to expect that selection cuttings such as are practiced on the National Forests (described in the chapter on "Management") will stimulate the reserved trees to more rapid growth, and such is found to be the case.

In a detailed study[1] of several areas in the Blue Mountains, partially logged over several years ago, the increase in the basal area growth of

[1] Manuscript report by R. H. Weitknecht, assistant forest ranger.

the reserved trees was found to be very large. On seven sample plots which were studied intensively it amounted to 310, 219, 242, 141, 103, 63, and 48 per cent, respectively. On these areas the increase in the growth rate was in inverse relation to the volume of the reserved trees on the sample plot. Where there were many trees left standing there was less stimulation than where there were few. The acceleration in growth was also more noticeable where the reserved trees were evenly distributed than where they were crowded into groups.

The measurement of a similar area in Klamath County lightly culled over some 24 years ago, on which "bull pines" and somewhat misshapen older trees were left, showed the increase in the growth of these reserved trees to have been surprisingly large since the thinning was made, amounting in one sample plot [1] to 105 per cent in the volume growth, and in another [2] to 63 per cent in the basal area growth.

Yellow pine's rate of growth responds quickly to changes in the soil moisture, soil depth, aspect, climate, density of the stand, etc.; and the changes in these factors are very frequent in the mountainous country such as yellow pine inhabits. Within the Blue Mountain region alone, on neighboring tracts (Winlock's Mill and Mill Creek) both of which support typical commercial yellow-pine stands, the volume growth of a 190-year-old tree is in the one case 3.7 board feet per year, and in the other 9.0, a range of 240 per cent.

STANDS.

It is easy to determine the rate of growth of individual trees, but extremely difficult to find out, even approximately, that of stands, especially when only uneven aged and virgin forests which are irregular in density are available for measurement. Theoretically, and actually on large areas, there is no net growth in the virgin forest; i. e., the growth of the living trees is just offset by the death of occasional old ones. Young trees take the place of the dying ones just rapidly enough to preserve indefinitely a uniform volume. Assuming that no trees died, the growth on an acre in such stands as those listed in Table 7 would probably be 100 board feet or more per year on average soils, and fully 200 feet on good soils.[3]

The forester, however, is particularly interested in the rate of growth that he can secure on lands that have been cut over under proper regulations. Until there is an opportunity to remeasure sample plots in areas which have been cut over, exact yield data of this character will be lacking. Estimates based upon the gross growth of virgin forests, which take into consideration the several

[1] Manuscript report, "Silvicultural Aspects of Cutting in Open Yellow-Pine Forests," by H. D. Foster, forest assistant.

[2] Manuscript report, "Notes Regarding Increased Growth in Yellow-Pine Stands as the Result of a Selection Cutting," by Thornton T. Munger, forest assistant.

[3] Growth rate of individual trees as shown in Table 11.

unmeasurable factors—lessened number of trees per acre after cutting, occasional loss of some trees on account of accidents, increased growth after cutting due to more growing space—point to the conclusion that central and eastern Oregon yellow-pine timberland can be counted upon to yield annually for an indefinite time from 75 board feet per acre on poor sites to 175 board feet on good sites. This is not large when compared with the 800 or 1,000 board feet per acre per year yields of the best Douglas-fir forests west of the Cascades; but the climate in the yellow-pine belt is such that the productivity of the forest soil is inevitably not large.

CHARACTERISTICS OF THE WOOD.

Botanically western yellow pine belongs to the subfamily of the hard or "yellow" pines rather than to that of the soft or "white" pines. In characteristics the wood is midway between the two. It is described as follows:[1]

Rather light, not strong, grain fine, even, often twisted; annual rings variable in width, summerwood broad or narrow, resinous; resin passages medium and rather numerous; medullary rays not numerous, prominent; color very light yellow to reddish, thick sapwood almost white; not durable in untreated condition, but readily receives treatment.

The smaller trees, i. e., the so-called "bull pines," and the centers of the larger trees have a coarse-grained wood, in which the annual rings are prominent and the summerwood rather hard, resembling that of some of the southern yellow pines. The outside of the larger trees, particularly of the slower-growing ones, is soft, uniform-textured, and resembles strongly the wood of the eastern white pine, western white pine (Idaho white pine), and sugar pine. The wood from the outside of the lower logs of old trees is apt to be fairly clear of knots, the worst defect in this lumber; but that from the upper part of the tree and from young trees is almost always knotty, even though the outside of the log may appear fairly smooth. Much of the yellow-pine timber cut in Oregon is so soft and white that it is shipped east and used with satisfaction for purposes for which real white pines and sugar pine have been used previously. The character of the wood varies with the situation, a fact well known to lumbermen, who find that the timber in certain localities produces a larger percentage of the high-grade soft "shop" lumber than that in other localities where it is similar in exterior appearance.

The following statistics summarize the characteristics of the wood.[2]

Average weight of oven-dry wood, 26.5 pounds per cubic foot. (Sargent.) (Exceptionally soft, light specimens from central Oregon weighed, air dry, 22 pounds per cubic foot.)

[1] Forest Service Bulletin 99, "Uses of Commercial Woods of the United States; II, Pines."

[2] For further description of the wood, see Forest Service Bulletin 101, "Western Yellow Pine in Arizona and New Mexico," by T. S. Woolsey, p. 33.

Specific gravity (dry), 0.42.

Fuel value, 63 per cent of that of white oak. (Sargent).

Average breaking strength (modulus of rupture) of small clear pieces, green 5,659, air dry 10,871 pounds per square inch, or 70 per cent that of green Douglas fir.

Average factor of stiffness (modulus of elasticity) of small clear pieces, green 1,159,000, air dry 1,534,000 pounds per square inch, or 65 per cent that of green Douglas fir.

Length of fiber, from 2.5 mm. to 3.3 mm.

Weight of 1,000 feet b. m. of green logs (assorted sizes from Blue Mountains, Oreg.), from 7,000 to 8,000 pounds.

Weight of 1,000 feet b. m. of rough green lumber, from 3,500 to 3,700 pounds.

Shipping weight of 1,000 feet b. m. of 1-inch rough air-dry lumber, 2,400 pounds.

UTILIZATION OF YELLOW-PINE FORESTS.

LUMBER.

The major product of yellow-pine forests is lumber in its various forms. Oregon's yellow pine has been cut for local use by small mills since the first settlement of the country some 60 years ago, but until the last 10 years relatively little extensive lumbering has been carried on. The yellow-pine cut-over lands therefore are chiefly in small patches adjoining small mills, and only in a few places, chiefly along the main line of the Oregon Washington Railroad and Navigation Co. and its tributary lines in the Blue Mountains, are there extensive stump lands.

Western yellow-pine lumber is used for almost every purpose to which any pine lumber is put. Through central and eastern Oregon, and in fact throughout most of its range, western yellow pine is the most abundant timber tree, and is superior to most of its associates for the large variety of purposes for which it is used. Many houses in Oregon are built entirely of yellow pine, even the shingles, floors, and trimmings. Besides what is used within the State for buildings, railroad structures, fencing, and construction purposes, Oregon exports a large amount of the better grades each year. That shipped from eastern Oregon goes largely to the timberless parts of the Rocky Mountain States, to the Middle West, and even to the East, where it is used as a general all-purpose factory material for the manufacture of doors, sash, finish, shelving, moldings, and special factory products, pattern material, bevel and drop siding, rustic ceiling, and flooring. Some of that shipped from southern Oregon goes to California and Nevada. Much of the lower-grade material is manufactured into boxes in the State, and large quantities go to California for fruit boxes.

FUEL, POSTS, ETC.

Yellow pine makes excellent fuel, for which both the green and the dead timber are used. In addition to being sawed for lumber and used for fuel, a very little is used in the State in the round for house logs and frames, fence rails, and posts, but for these purposes it is

inferior to its associates, western larch, Douglas fir, and lodgepole pine. It is only the "pitchy" parts of the tree that are durable in the ground and are prized for posts.

PULP.

Western yellow-pine wood has never been used commercially for paper. Experiments made with it at the Forest Products Laboratory of the Forest Service indicate that it has decided possibilities for this purpose. With the soda process it yielded per cord 1,470 pounds of pulp, the fiber of which was strong and of brown color, and which would probably make a good grade of wrapping paper. By the mechanical process it yielded 2,290 pounds of pulp, which had long fibers and was creamy in color, but coarse and suitable only for making manila and other papers where color and coarseness are of no importance.

STOCK GRAZING.

One minor use, grazing of stock, and a suggested use, the extraction of naval stores, deserve especial mention in considering the utilization of yellow-pine forests.

In the yellow-pine forests of Oregon (except those on both slopes of the Cascades south of Crater Lake and those on the Siskiyou Mountains in southern Oregon and on some of the pumice-stone land toward the head of the Deschutes River) the trees are so open-grown and the woods are so free of underbrush that a good herbaceous vegetation suitable for forage springs up each year. The character of the vegetation depends upon the region, but it usually consists in part of a variety of grasses and in part of "weeds" (annual flowering plants). In the Blue Mountains the herbage is rather more luxuriant and varied than on the eastern slopes of the Cascades and their outstanding ranges. In the early summer the open yellow-pine forests of the former region are as green with fresh herbage as a lawn, except here and there where the green is tinged with patches of yellow or purple flowers. Some of this luxuriant herbage is pine grass (*Calamagrostis* sp.), a plant which is not eaten by stock except very early in the season; but much of the ground cover makes excellent range for cattle and sheep. Nearly all the yellow-pine land in the State which is not too brushy or too sandy is grazed by one or the other of these classes of stock. It is thought that 3 acres will support a grown sheep (or a ewe and lamb) during the summer season, and 15 acres will support a cow. This makes the forage worth annually 5 or 10 cents an acre, which is a very decided additional revenue for the owners of forest land.

TURPENTINING.

In several particulars western yellow pine is similar to longleaf pine (*Pinus palustris*) of the South Atlantic and Gulf States, which is so valuable as a source of naval stores—turpentine and rosin.

Recent experiments in turpentining western yellow pine in Arizona and California [1] show that its yield of turpentine and rosin is very similar to that of the southeastern pines, comparing very favorably with that from longleaf pine (*Pinus palustris*). Although the season of flow was four or five weeks shorter in Arizona than in Florida, the yield of "gum" was about four-fifths as large for equal periods.

So far as is known, yellow pine has never been tapped for turpentine on a commercial scale in Oregon. In the summers of 1912 and 1913 experiments were undertaken by the Forest Service in Grant County to determine whether yellow pine in this locality would yield enough crude gum by the usual methods of tapping and whether its gum was of good enough quality to be of commercial value. The results obtained were not encouraging.[2] In 1912, 199 cups were hung on 108 trees and they yielded in a 21-week season 0.111 pound of gum per cup per week. In 1913, 201 cups were hung on 101 trees and they yielded in a 21-week season only 0.069 pound per cup per week. On the basis of 31-week seasons this is only 39 and 28 per cent, respectively, of the average Florida yield from longleaf pine. While the resin flowed throughout the season and was of good quality, the yield was so small as not to be commercially profitable under present conditions. The indications are that the nights are too cold and the warm season too short to allow of an abundant flow. It is the conclusion that under present economic conditions in the naval-stores industry turpentining of yellow pines in Oregon on a commercial scale is impracticable. With the exhaustion of the supply of more easily tapped trees elsewhere turpentining of yellow pine may become profitable. If so, it would undoubtedly have a marked influence upon the handling of timberlands and be an added source of revenue to their owners.

LOGGING AND MILLING.

METHODS OF LOGGING.

Yellow-pine logging is ordinarily done with horses, various methods being used according to the density of the timber, the topography, and the length of the haul.

The timber is felled with the saw (Pl. V), and bucked into from 12 to 20 foot, usually 16-foot, log lengths, sometimes the same crew doing the felling and the bucking, and sometimes the latter operation being done by special buckers working singly. The smooth, straight trees are utilized to a top diameter inside the bark of 6 or 8 inches, occasionally to an even lower limit; large trees with heavy branches or a crooked main stem are often not usable below 16 inches. Yellow

[1] Forest Service Bulletin 116, "Possibilities of Western Pines as a Source of Naval Stores," by H. S. Betts.

[2] Manuscript reports of J. B. Knapp, assistant district forester, "Turpentining Western Yellow Pine in Oregon," and of H. B. Oakleaf, forest examiner, "Turpentining Experiments on Western Yellow Pine Conducted on the Whitman National Forest."

FELLING A LARGE WESTERN YELLOW PINE IN KLAMATH COUNTY, OREG.

Showing the mixed forest of yellow pine, sugar pine, and white fir, and brushy ground cover which is characteristic of this region.

HAULING A LOAD OF LOGS FROM WOODS TO LANDING ON FOUR-WHEELED WAGON, KLAMATH COUNTY, OREG.

In background is a mixed yellow pine forest which has been cut over under the selection system.

pine falls heavily in open woods and is rather brittle, so that the breakage is bad unless the ground is smooth and care is taken by the felling crew to prevent crossing. The felling and bucking are done very commonly by contract, 70 cents per tree being now (1915) the usual price for these operations.

Usually the logs are first "bunched" or "skidded" with a team of horses and a pair of tongs, or with a team and a spool cart or a sled "go-devil," these methods being used for distances less than one-eighth of a mile except on a downhill pull, where they may be practicable for a quarter-mile haul. In case the distance is short the logs are brought directly to the railroad "landings" by one of these methods. Otherwise they are transported from the "bunches" to the mill or pond, or to the railroad, on four-wheeled trucks, or with "high" wheels. (See Pl. VI.) In practically every large yellow-pine operation in the State logging railroads are being used for carrying the logs from the points that can be reached economically by horses to their final destination at the mill. In some small operations the logs are hauled on trucks 2 miles or so, but where railroads are used the spurs are usually constructed so frequently that a haul with horses of over one-quarter mile will not be necessary for any considerable body of timber. In a few operations, where railroad construction is not feasible, a traction engine is being used to haul great wagonloads of logs for considerable distances along country roads from the woods to the mill.

Most of the yellow-pine timber in Oregon which is now being exploited and in which logging is likely to be carried on in the next few years is ideal for horse and railroad logging. The timber is of a size convenient for handling, the topography is ordinarily not too rugged nor the ground too rough, and the forest is open and fairly free of underbrush, so that little swamping is necessary. The climate and snow conditions are such that horse logging may be conducted nearly throughout the year in most parts of the yellow-pine region, though fewer operations are in progress during the winter. In a few instances logging yellow pine with steam skidders or with steam donkeys has been tried, but these methods have in some instances been unprofitable and do not seem to be coming into general use except on ground too steep for horses. In certain kinds of topography steam donkey logging is practicable where horse logging would be out of the question. River driving of yellow pine is practically not done at all in this State, and probably never will be to any large extent because of the scarcity of suitable streams. Klamath Lake is used as a waterway across which logs are towed from the woods to the mills.

The cost of logging yellow pine varies greatly with the local conditions—length of haul, lay of the ground, character and density of the timber, wage scale, efficiency of labor, etc. The following figures

may be considered to represent the present average cost of an average operation in which 60,000 board feet are being taken each day from the standing timber and loaded on the log cars, using the ordinary methods of horse logging.

TABLE 12.—*Cost per thousand feet b. m. of logging yellow pine for an average sample operation.*

Operation.	Cost per 1,000 feet b. m.
Felling and bucking	$0.70
Brush piling and burning	.30
Hauling by horses, stump to landing	1.20
Loading	.20
Supervision	.10
Interest, depreciation, liability insurance, taxes, etc.	.30
Total	2.80

MILLING.

There are all kinds of sawmills cutting yellow pine in Oregon, from the small portable mill that can cut not more than 6,000 feet of logs a day and runs only a few days a year to the large band mill that cuts 150,000 feet in 10 hours and runs day and night throughout the year. Altogether, there are in the State about 100 mills that cut yellow pine chiefly, and their aggregate daily capacity is a little under 2,000,000 feet, which would be equivalent to 600,000,000 feet per annum if every mill ran 300 days a year. Since many of them operate only a fraction of the time and cut other species of timber as well, the output in 1915 of the 134 mills that reported cutting some yellow pine was 189,203,000 feet, which was 15.1 per cent of the whole country's cut of this species. At the present time there are in Oregon less than 20 mills cutting chiefly yellow pine that have a 10-hour capacity of over 35,000 feet, and only 4 that have a capacity of 80,000 feet or more. Each year, however, new mills are being built.

Most of the smaller mills that cut for the local use of the community are equipped with a planer, upon which the better grades of boards are dressed for use as finishing lumber. The larger sawmills have elaborately equipped planing mills where the rough boards are kiln dried, resawed, surfaced, and dressed to such styles and sizes as will find the most ready sale in the eastern markets and bring prices that will repay the heavy transportation charges.

In the smaller mills the lumber is either sold "mill run" without grading or it is graded into "finishing lumber" (which is surfaced and sized), "common," and "cull" lumber. In the larger mills the lumber is carefully graded according to the specifications of the lumber associations.

LUMBER GRADES.

In Oregon two sets of grades are used, one in use through all the eastern part of the State, and the other in southern Oregon where the lumber is shipped to California. Table 13 shows the names of the principal grades and their average prevailing values f. o. b. mill or railroad during the past two years in two representative regions, the Blue Mountains and the Klamath Lake region. It should be remembered that the value of each grade is constantly changing and that the percentage of grade is very variable from tract to tract. The table is therefore an illustration, not a mathematical average:

TABLE 13.—*Average value of the various grades of lumber from two typical yellow-pine regions in Oregon.*

Blue Mountain region.		Klamath region.	
Name of grade.	Value per M feet.	Name of grade.	Value per M feet.
B select and better	$35 to $45	Nos. 1 and 2 clear	About $35.00
C select	30 to 37	No. 3 clear	About 30.00
D select	20 to 28	C select	About 30.00
No. 1 shop	25 to 28	No. 1 shop	About 24.00
No. 2 shop	16 to 19	No. 2 shop	About 17.00
No. 3 shop	11 to 14	Box	About 12.50
No. 1 common	21 to 24		
No. 2 common	14 to 18		
No. 3 common	11 to 14		
No. 4 common	8 to 10		

PLANTING.

Direct seeding with yellow pine in Oregon, either by sowing the seed broadcast or in prepared spots, does not promise good results so far as is indicated by the experiments already made. Better results will undoubtedly be secured by the planting of nursery-grown seedlings, though it will cost more initially. Since yellow pine produces such a long taproot, it is rather a difficult species to handle in the nursery and in field planting; therefore, plants older than 2 or 3 years, i. e., those about 6 inches tall, can not ordinarily be used profitably in forestation work. As yet, but little planting of yellow pine has been done in Oregon, and the experimental areas so far planted aggregate less than 100 acres; but the indications are that careful methods on reasonably appropriate sites will give satisfactory results. The average cost of establishing a forest plantation of yellow pine, 800 trees to the acre, is estimated as follows:

	Per acre.
Cost price of 2-year-old, once transplanted nursery trees, boxed for shipping	$3.50
Average cost of shipping stock to planting site and heeling it in	.50
Average cost of setting out the trees	5.00
Total cost	9.00

MANAGEMENT OF WESTERN YELLOW PINE FORESTS.

The economic conditions which affect the management of timberland held in public ownership are so different from those which control the management of privately owned lands that a separate discussion of each class is necessary. The administration of public forests, such as those held by the Federal and State Governments, is aimed to secure the greatest good to all concerned for all time; i. e., present-day financial returns are secondary to the larger considerations of sustained profit and public welfare. Privately owned forests must be so administered as to yield the greatest present-day profits, and this usually means harvesting the maximum yield within the lifetime of the individual owner. Table 14 shows the proportion of yellow-pine timberland in Oregon held under each class of ownership.

TABLE 14.—*Ownership of the yellow-pine forests of Oregon, 1913.*

Character of ownership.	Area.		Volume.	
	Acres.	Per cent.	Feet b. m.	Per cent.
In private ownership	4,448,026	44.4	34,812,400,000	48.6
In State ownership	16,332	.2	51,400,000	.1
In Federal ownership: [1]				
National forests	4,742,148	47.4	27,398,300,000	38.5
Indian reservations	800,000	8.0	9,100,000,000	12.8
Total	10,006,506	100.0	71,362,100,000	100.0

[1] To this might be added two or three hundred thousand acres in the public domain which carries four million feet of yellow pine, most of which is too scattered and of too inferior quality to be considered of commercial importance.

FOREST MANAGEMENT OF PUBLIC LANDS.

It is the policy of the Federal Government to administer the public forest lands in such a way as to perpetuate the forest on all the land which is better suited to the production of timber than anything else, and to make it yield for all time the greatest quantity and the best quality of timber.

The perpetuation and proper utilization of the public forests of yellow pine, i. e., the practice of forestry on these lands, consists of four lines of work: (1) The protection of the virgin forest from fire; (2) the cutting of the mature trees in such a way that the immature trees will be spared from injury; (3) the intensive utilization of all the merchantable timber designated for cutting; and (4) the proper disposal of the logging débris in order to make possible the subsequent protection of the stand of immature timber from fire.

PROTECTION OF THE VIRGIN FOREST FROM FIRE.

It has been shown that the normal yellow-pine forest in Oregon is many-aged and that it should have an abundance of trees of the younger age classes along with the old trees. Absolute fire protection of the virgin woods is necessary, therefore, not alone to prevent the damage or killing of commercial trees, but to prevent depreciation in the future yields.

A MIXED STAND ON THE NATIONAL FOREST IN KLAMATH COUNTY, OREG., WHICH HAS BEEN CUT OVER RECENTLY UNDER THE SELECTION SYSTEM, ILLUSTRATING THE KIND OF IMMATURE TREES THAT MAY BE RESERVED FOR A SECOND CROP.

The brush has been piled but not yet burned.

Ordinarily, a fire in yellow-pine woods is comparatively easy to check. Its advance under usual conditions may be stopped by patrolmen on a fire line a foot or so wide, either with or without backfiring. The open character of the woods makes the construction of fire lines relatively easy, and in many places horses may be used to plow them. The first consideration is to remove the causes of fires, and the second is to detect at their incipiency those that do start, so that they may be suppressed before they have spread to an unwieldy size. With a system of lookouts and patrolmen, a convenient supply of tools and laborers, a reasonably quick means of getting fire fighters to all parts of a tract, and with the exercise of care not to start fires, it is possible, at reasonable cost, to eliminate forest fires larger in extent than a few acres from most of the yellow-pine forests of Oregon. In a few particularly brushy areas, such as the southern Cascades and Siskiyou Mountains, these precautions will give less assurance of success.

The following are samples of the provisions of proved practicability which are placed in contracts between the Government and permittees who are operating on the National Forests.

In order to check the spread of forest-tree diseases and to eliminate snags which constitute a fire menace, we agree to cut all trees or snags marked upon the sale area whether merchantable or apparently unmerchantable; provided, however, that the number of such trees and snags to be so cut shall not exceed an average of 2 per acre for the whole area included in the sale. * * *

During the period from May 1 to October 1 of each year all locomotives, donkey engines, or other steam-power engines shall burn oil or shall be equipped with spark arresters acceptable to the forest officer in charge, with a connected steam force pump with not less than a 1-inch discharge, 100 feet of serviceable 1-inch fire hose, six 12-quart pails, 6 shovels, and a constant supply of not less than the equivalent of 12 barrels of water, this equipment to be suitable for fire-fighting purposes, and kept in serviceable condition. During this period the purchaser may be required in the discretion of the forest supervisor to patrol all railroad tracks after the passage of each locomotive.

No refuse shall be burned during the period from June 1 to October 1 of each year without the written consent of the forest supervisor.

Whenever necessary in the judgment of the forest officer, the purchaser shall clear and keep clear the railroad rights of way of all inflammable material, including snags and dead trees, for a distance of not to exceed 100 feet on each side of the center of main and spur tracks, in such manner and at such times as may be designated by the forest officer in charge.

CUTTING THE MATURE TIMBER.

Many of the trees in the virgin woods, though large enough to be merchantable, are not mature or "ripe" (bull pines, so called), and should not be cut until they reach their maximum volume productivity and best quality.

The sudden removal of the forest cover in this dry climate is apt so to expose the soil to sun and desiccating winds that its productive capacity would be lessened, making difficult or impossible the starting of reproduction, a serious condition if there is not enough advance reproduction on the ground.

Yellow pine in its middle life and old age demands so much light and ground space that the soil is put to the most intensive use only when the forests are uneven-aged, so that the younger trees may pass their slow-growing sapling stage in the gaps between the big trees.

The system of cutting which seems to be ideal for this type of forest is a form of selection cutting. Periodic cuttings are made, in each of which all the overmature and thoroughly ripe trees in the stand and all the defective ones are removed; and the saplings, poles, and young, thrifty trees are left standing to form the basis for the next crop. No tree is removed until it has reached its majority, so to speak, and no old, slow-growing tree is allowed to stand and occupy space which should be devoted to young and rapid-growing trees. In this way the forest is kept at its maximum productivity and the continuity of the forest cover is not interrupted. In each cutting, under the practice of the Forest Service in Oregon, from 10 to 30 per cent of the volume of the stand (above 12 inches in diameter) is left. This is equivalent to 55 per cent of the trees over 12 inches in diameter by number. It is anticipated that a cutting of this character may be made at intervals of from 40 to 60 years, and that there will be a yield sufficient to justify logging.

Each tree which is to be cut is marked or "blazed" with an ax by a woodsman who has experience, a trained eye, and good judgment. He decides for every tree as he passes through the forest whether it shall be cut or reserved. A woodsman may effectually mark in a day 40 acres, or half a million feet. It is customary to set an approximate diameter limit of from 16 to 22 inches, the majority of the trees above which limit are cut, and those below left; in actual practice this diameter limit must be very elastic, it often being wise silviculturally to reserve a tree 30 or more inches in diameter while one of 14 inches must be cut.

The following classes of trees should be cut. They are arranged according to the desirability of their removal:

(*a*) All spike-topped, seriously fire-scarred, lightning-struck, or otherwise defective, yet merchantable, trees.

(*b*) All insect-infested and conky trees.

(*c*) All suppressed trees which apparently would not thrive and make good growth even if released.

(*d*) All thoroughly mature trees of all species which apparently will not survive until the next cutting. (In this class should be included all trees liable to windthrow, which is a serious menace on certain sites.)

(*e*) Enough of the younger trees which would probably survive until the next cutting to give the remaining trees plenty of room for optimum growth and allow the saplings and seedlings to receive overhead light.[1] The cutting, therefore, should be in the nature of an improvement cutting. Though the trees that are left are not reserved as seed trees, but rather as the basis for the next cut, many

[1] Manuscript report by Forest Supervisor M. L. Merritt.

of them are large enough to produce seed, and will serve for this purpose in case an accidental surface fire gets into the cut-over area and kills off the advance reproduction of seedlings and small saplings.

Where the yellow pine occurs in small groups in which all the trees are of an even age, the cutting should be to a certain extent group-wise, it being an object to cut out *in toto* the groups of very old trees and leave almost intact the groups of very thrifty trees. The clean-cut gaps should not be made large, since it is wise not to open up the stand too heavily and allow drying winds to get at the soil, or chaparral to come in and occupy the ground to the exclusion of young yellow pines.

While the selection method of cutting makes the cost of logging a little greater than it would be were every merchantable tree cut, this increase is partly, if not wholly, compensated for by the fact that the average value of the trees cut by this system is higher. The "bull pines" that are left, though merchantable, are so heavy, knotty, and sappy that they are not so profitable for the lumberman to pay stumpage for and to manufacture as the older "yellow pines." In Appendix C (see p. 46) are given, in full, "Instructions for marking timber in the yellow-pine region, District 6," which are in effect in the administration of timber sales on the National Forests of Oregon. In contracts for the sale by the Department of Agriculture of yellow-pine stumpage, clauses similar to the following are being used in order to provide for the cutting of the timber by the permittees according to the methods described above:

It is agreed that this sale includes all the merchantable dead timber standing and down on the areas designated for cutting by the forest officer, and not less than 85 per cent by volume of the total stand of merchantable live timber in trees 12 inches and over in diameter at a point 4½ feet above the ground on such designated areas, to be marked for cutting by the forest officer in charge.

No unnecessary damage shall be done to young growth or to trees left standing, and no trees shall be left lodged in the process of felling. Unmarked or undesignated trees which are badly damaged in logging shall be cut if required by the forest officer in charge.

All marked trees shall be cut. No live timber shall be cut except that marked.

INTENSIVE UTILIZATION.

One of the essentials of forestry is to secure a close utilization of the forest: to cut all merchantable dead trees and all living trees that are ripe for the ax; to cut the inferior species along with the major species, so that the forest may not degenerate; to use each tree intensively, so that there may be no waste in high stumps, large tops, or in partly defective yet usable portions of the tree. To secure this conservative intensive use, provisions similar to the following are introduced in National Forest timber-sale contracts, and they are proving to be both effective and practical:

All cutting shall be done with a saw when possible; stumps shall be cut so as to cause the least practicable waste, and not higher than 18 inches on the side adjacent to the highest ground, except in unusual cases when, in the discretion of the forest officer in charge, this height is not considered practicable; all trees shall be utilized to as low a

diameter in the tops as practicable so as to cause the least waste, and to a minimum diameter of 7 inches when merchantable in the judgment of the forest officer in charge. The log lengths shall be varied so as to make this utilization possible.

All yellow-pine logs are merchantable under the terms of this agreement which are not less than 10 feet long, at least 8 inches in diameter inside bark at the small end, and, after deductions for visible indications of defect, scale 33 per cent of their gross scale. * * *

DISPOSAL OF THE LOGGING DÉBRIS.

The brush left after logging decays slowly in the dry climate of eastern Oregon, and the fire season is long. Slashings on which the brush is not disposed of properly are serious fire menaces. If they become ignited they make a bad fire which is apt to destroy all the young trees so carefully reserved in the logging and those which have sprung up afterwards. The brush should be piled as the logging proceeds, in small compact piles, away from the bases of reserved trees and as far as possible from groups of reproduction. When the piles become dry enough and the season is such that there is no danger of a general conflagration, preferably in the late fall, the piles should be burned. The danger of a severe fire within the next few years is then practically removed. The cost of lopping the larger pieces of débris and piling all the brush in a thorough fashion amounts to somewhat less than 25 cents for each thousand feet of timber logged, and the cost of burning it amounts to a few cents more.

Besides creating a security against fires, the piling and burning of the brush has added advantages; it makes the logging decidedly easier, since, if the piles are properly located, the teamsters and horses can more readily get to the logs to haul them out, and it also tends to prevent the inordinate increase of bark beetles and other insect enemies that breed freely in logging débris.

In exceptionally dry situations where reproduction is scanty and has difficulty in becoming established, as on the pumice soils of the Klamath-Deschutes divide, it may be better forest management to scatter the brush as a mulch over the surface of the ground, in order that it may assist in preventing the evaporation of moisture from the soil and in shielding the young seedlings from hot sun, dry winds, and frost. The method is being tried on a small scale experimentally by the Forest Service at the present time and is used quite generally in the Southwest, where the fire risk is less and reproduction is difficult. But it should be used only in localities where the fire risk is small, as where the trees are scattered and the brush does not make a continuous or heavy cover. At all events, fire lines or strips on which all the brush is burned should be built, so that should a fire get into the débris it could be confined to a small area.

To enforce the proper disposal of the slash on sales of stumpage on the National Forests, a clause such as the following is being used in the contracts with the permittees:

Tops of all trees felled, whether merchantable or nonmerchantable, shall be lopped, and all brush piled compactly at a safe distance from living trees, as directed by the forest officer in charge.

FOREST MANAGEMENT OF PRIVATE LANDS.

At the present time yellow-pine stands on privately owned lands in Oregon are usually logged with no thought of securing a second crop of timber on the land cut over. All the merchantable timber is cut, the brush is allowed to lie where it falls, and the area is given no protection from fire. As a result, fire usually gets into these slashings and consumes many of the seedlings and saplings which were on the ground as "advance reproduction" before the cutting. There being no seed trees, the area does not reforest, but remains unstocked, or inadequately stocked, practically an unproductive waste of idle land. Such land is usually retained by the owner because it yields a rental for grazing purposes, which about equals the taxes upon it.

A part of the yellow-pine land which has been cut over already is adapted to agriculture, and therefore it has quite naturally been an object of the owner to remove the timber in such a way as to annihilate the forest. But the majority of the yellow-pine land in the State is absolute forest land; i. e., it is too dry, or too rocky, or too steep, or at too high an altitude for agriculture and is land which serves its greatest usefulness in the production of forest crops. Where such absolute forest land has become reforested after destructive lumbering, it has been by chance rather than by the intent of the operator.

It has been necessary up to the present time, because of economic conditions, that the logging should be of a destructive nature. However, with the rapidly increasing value of stumpage the probability of reform in timberland taxation, the greater security against forest fires, and the increased stability and confidence in timberland investment, it can be said confidently that the time is here when the yellow-pine timber operator in Oregon can afford to do something toward conducting his logging operations and handling his cut-over lands so that they will remain productive of forest crops. The Government can afford to leave standing from 10 to 30 per cent of an uneven-aged forest as the basis of a second cut, and allow it to grow for 50 or 60 years, but the individual owner can not afford to tie up an investment in slow-growing timber for this length of time unless a speculative rise in the value of the reserve stumpage be counted upon. In short, the individual owner must take off the tract all the timber that he can market at a profit in order to defray his logging and fixed charges and to get back his invested capital; but even if he must cut off of the tract all the merchantable trees, and can not follow the method practicable on public lands, there are several measures which he can adopt to promote the growth of future crops of timber and to make the tract more valuable. The raising of such a second crop is in no wise incompatible with the use of the land for grazing.

1. He can protect the virgin woods from fire. This is being done with fair success now on many private holdings in the State, and all the indications are that it will be universal and effective throughout the yellow-pine region of Oregon before many years.

2. He can conduct the logging so that the seedlings and saplings, small poles, and occasional large unmerchantable yellow pines which are present in all stands will be spared and protected against forest fires. Misshapen or undersized yellow pines which it will not be financially profitable to handle may be allowed to stand, for such trees may make useful seed trees. Sometimes loggers now cut 10-inch and 12-inch "bull pines" which are so small and yield such sappy, knotty lumber that it is doubtful if their contents pay for their handling. If such trees were left standing, the owner would be out nothing and yet would have his land in better condition for producing a second forest crop; and this would enhance its value even though the second crop should not be as good as would be obtained under a conservative selection method of cutting.

3. Every tree both dead and alive of all species should be utilized, both in the woods and in the mill, to the utmost degree of practicability. The saving effected by intensive utilization may help to defray the cost of brush disposal.

4. The brush should be piled and burned or otherwise disposed of, so that the area will be immune from subsequent destructive fires. Disposal of the brush will also benefit the grazing. The State law now requires all slashings to be burned each year.[1]

It may be assumed that the first recommendation will be observed anyway by all timberland owners. Of the last three provisions, the disposal of the brush is the only one that should cost the operator or owner anything, and this piling and burning costs but little more than the slash burning required by law of all timberland owners and operators throughout the State. It is believed that the small amount of money spent in brush piling and burning (perhaps 30 cents for each thousand feet cut) is a good investment for the timberland owner and will repay him in—

(*a*) Increased ease in logging.
(*b*) Improved range for stock.
(*c*) Added safety of surrounding uncut timber and of adjoining logging investments against fire.
(*d*) Insurance of the young reserved seedlings and poles (the oncoming crop) against disastrous fires during the next few years.

The observance of these simple principles, which require no revolution in present logging methods, and which add but a trifle to the present logging costs, seems well worth while for the owner who is operating in yellow pine and is planning to hold his cut-over land anyway. Cut-over land which has a second crop started should be worth more some years hence than land that is absolutely denuded. And if this second crop is secured without cost other than the charges of holding the land, any increase in the value of the land on account of its second crop is net gain.

[1] Chapter 278, section 11, Laws of Oregon, 1911.

APPENDIX A.

THE BLUE MOUNTAIN VOLUME TABLE FOR WESTERN YELLOW PINE.

This volume table is based on the measurement in 1910 of 1,536 felled western yellow pines which had grown under average conditions in northeastern Oregon in Union, Baker, and Grant Counties. It is a combination of the Austin, Oreg., and the Lookingglass Creek, Oreg., volume tables. The trees were scaled by the Scribner rule according to Forest Service usage, the stumps being never higher than the diameter of the tree at breastheight, the trees being utilized as thoroughly as practicable, but not to less than 6 inches diameter inside bark at top of last log, the logs being cut into 16, 14, or 12 foot lengths and 2 inches being allowed for trimming on each log. No allowance was made for decay, breakage, or other abnormal defect. All volumes evened off on curves.—T. T. MUNGER and G. A. BRIGHT.

Diameter at breast-height.	Number of 16-foot logs.														Average of all heights.	Average diameter inside bark, top of last log.
	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½		
	Volume of tree, in board feet, Scribner rule.															
Inches.															*Bd. ft.*	*Inches.*
10	35	50	65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	50	6.3
11	50	65	80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	65	6.2
12	65	80	95	120	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	90	6.5
13	80	95	115	140	170	210	.....	.....	.....	.....	.....	.....	.....	.....	125	6.4
14	95	110	130	160	195	230	285	.....	.....	.....	.....	.....	.....	.....	160	6.5
15	110	130	150	180	215	260	315	.....	.....	.....	.....	.....	.....	.....	200	6.4
16	130	150	180	200	240	290	340	400	470	.....	.....	.....	.....	.....	245	6.7
17	150	170	200	225	270	315	375	435	500	.....	.....	.....	.....	.....	295	6.7
18	.....	195	220	255	300	350	405	465	535	630	.....	.....	.....	.....	350	6.6
19	.....	225	255	290	335	385	440	505	575	665	.....	.....	.....	.....	410	6.8
20	.....	260	290	325	365	415	470	535	610	705	820	.....	.....	.....	480	6.9
21	.....	.....	.....	385	415	455	510	575	655	750	865	.....	.....	.....	560	6.8
22	.....	.....	.....	440	475	515	565	630	705	800	915	1,050	.....	.....	645	7.0
23	.....	.....	.....	500	530	570	620	680	760	855	970	1,100	.....	.....	740	7.0
24	.....	.....	.....	.....	595	630	680	745	820	915	1,030	1,170	.....	.....	840	7.2
25	.....	.....	.....	.....	655	700	755	820	900	1,000	1,115	1,260	.....	.....	940	7.3
26	.....	.....	.....	.....	720	765	825	900	985	1,090	1,210	1,340	.....	.....	1,050	7.4
27	.....	.....	.....	.....	800	855	915	990	1,080	1,180	1,300	1,430	1,570	.....	1,170	7.3
28	.....	.....	.....	.....	885	940	1,010	1,090	1,190	1,300	1,420	1,560	1,700	.....	1,300	8.1
29	.....	.....	.....	.....	985	1,040	1,120	1,210	1,310	1,430	1,550	1,690	1,830	.....	1,440	7.9
30	.....	.....	.....	.....	1,090	1,160	1,250	1,340	1,450	1,570	1,700	1,840	1,990	.....	1,590	8.0
31	.....	.....	.....	.....	.....	1,260	1,360	1,470	1,590	1,720	1,860	2,010	2,160	2,330	1,750	8.5
32	.....	.....	.....	.....	.....	1,370	1,470	1,600	1,730	1,870	2,020	2,180	2,340	2,520	1,920	8.5
33	.....	.....	.....	.....	.....	.....	1,620	1,750	1,890	2,040	2,200	2,370	2,550	2,740	2,090	8.5
34	.....	.....	.....	.....	.....	.....	1,760	1,910	2,060	2,220	2,380	2,560	2,740	2,960	2,270	9.4
35	.....	.....	.....	.....	.....	.....	1,920	2,080	2,240	2,410	2,580	2,760	2,950	3,160	2,450	9.3
36	.....	.....	.....	.....	.....	.....	2,100	2,250	2,410	2,580	2,760	2,950	3,150	3,360	2,630	11.7
37	.....	.....	.....	.....	.....	.....	2,260	2,420	2,580	2,750	2,940	3,140	3,360	3,580	2,820	8.9
38	.....	.....	.....	.....	.....	.....	2,410	2,560	2,740	2,930	3,130	3,330	3,560	3,800	3,000	11.1
39	.....	.....	.....	.....	.....	.....	.....	2,700	2,880	3,080	3,280	3,500	3,750	4,000	3,170	13.6
40	.....	.....	.....	.....	.....	.....	.....	2,840	3,030	3,240	3,460	3,690	3,940	4,220	3,330	12.9
41	.....	.....	.....	.....	.....	.....	.....	2,960	3,170	3,380	3,610	3,850	4,100	4,400	3,480	16.8
42	.....	.....	.....	.....	.....	.....	.....	3,080	3,290	3,510	3,740	3,990	4,250	4,580	3,630	9.4

APPENDIX B.

THE KLAMATH VOLUME TABLE FOR WESTERN YELLOW PINE.

This volume table is based on the measurement in 1910 of 823 felled western yellow pines which had grown under average conditions in southwestern Klamath County, Oreg., most of them in the vicinity of Pelican Bay and some near Keno and Meadow Lake. The trees were scaled by Scribner rule according to Forest Service usage, the stumps being never greater than the diameter of the tree at breastheight, the tree being utilized as thoroughly as practicable but not to less than 6 inches inside the bark at top of last log, the logs being cut into 16-foot lengths or less, and 2 inches being allowed for trimming on each log. The third from the last column shows, for trees of each diameter class, all heights being averaged together, the actual volume which was utilized in trees cut in Forest Service sales near Pelican Bay, allowance having been made for basal scars, visible decay, and unavoidable wastage in falling. The next to the last column shows the percentage by which this actual available volume is less than the possible merchantable volume. Volumes evened off on curves.—T. T. MUNGER and H. A. WINKENWERDER.

Diameter at breast-height.	Not allowing for decay, breakage, or other abnormal defect.														Allowing for basal scars, visible decay, and unavoidable waste in falling.		Average diameter inside bark top of last log.
	Number of 16-foot logs.													Average of all heights.	Average of all heights.	Percentage of allowance.	
	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½			
	Volume of tree in board feet, Scribner rule.																
Inches.															*Bd. ft.*	*Bd. ft.*		*Inches.*
12	80	85	95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	85	85	.....	.....
13	80	90	100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	90	90	.....	.....
14	85	95	110	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	105	105	.....	7.1
15	90	105	120	145	175	.....	.....	.....	.....	.....	.....	.....	.....	.....	140	140	.....	6.9
16	95	115	135	160	200	245	300	.....	.....	.....	.....	.....	.....	.....	185	185	.....	6.6
17	.....	130	150	185	225	275	330	.....	.....	.....	.....	.....	.....	.....	240	240	.....	6.6
18	.....	150	170	210	255	315	370	455	545	.....	.....	.....	.....	.....	300	300	.....	6.8
19	.....	175	195	245	295	355	415	495	595	.....	.....	.....	.....	.....	355	355	.....	6.8
20	.....	205	225	280	335	400	465	545	645	755	.....	.....	.....	.....	415	415	.....	7.2
21	.....	235	260	320	375	450	520	600	710	830	.....	.....	.....	.....	485	480	1.0	7.2
22	.....	.....	.....	375	430	505	580	665	780	900	.....	.....	.....	.....	565	555	1.8	7.3
23	.....	.....	.....	435	490	565	645	735	850	980	.....	.....	.....	.....	655	640	2.3	7.4
24	.....	.....	.....	500	555	630	710	805	920	1,055	1,140	1,190	.....	.....	750	730	2.6	8.1
25	.....	.....	.....	575	630	705	780	885	1,005	1,130	1,220	1,275	.....	.....	855	825	3.5	7.8
26	.....	.....	.....	655	710	785	870	980	1,090	1,220	1,310	1,360	.....	.....	965	930	3.6	7.8
27	.....	.....	.....	740	805	880	965	1,080	1,195	1,320	1,400	1,450	.....	.....	1,085	1,040	4.1	8.5
28	.....	.....	.....	830	900	980	1,070	1,180	1,300	1,420	1,495	1,550	1,600	.....	1,215	1,160	4.5	7.5
29	.....	.....	.....	925	1,000	1,090	1,185	1,295	1,410	1,515	1,585	1,645	1,695	.....	1,350	1,280	5.2	7.6
30	.....	.....	.....	.....	.....	1,200	1,305	1,410	1,515	1,610	1,685	1,745	1,805	.....	1,490	1,410	4.9	8.7
31	.....	.....	.....	.....	.....	1,310	1,400	1,515	1,620	1,715	1,795	1,870	1,935	.....	1,635	1,550	5.2	8.4
32	.....	.....	.....	.....	.....	.....	1,500	1,620	1,730	1,835	1,925	2,010	2,090	2,170	1,790	1,705	4.8	8.9

33	....	....	....	....	....	....	1,600	1,745	1,870	1,990	2,090	2,180	2,260	2,330	1,950	1,870	4.1	8.7
34	....	....	....	....	....	....	1,700	1,880	2,025	2,150	2,260	2,350	2,420	2,500	2,120	2,040	3.8	8.8
35	....	....	....	....	....	....	1,800	2,000	2,160	2,300	2,420	2,520	2,610	2,690	2,295	2,220	3.3	8.6
36	....	....	....	....	....	....	1,900	2,125	2,305	2,470	2,600	2,720	2,830	2,920	2,480	2,410	2.9	9.4
37	....	....	....	....	....	....	2,020	2,250	2,460	2,640	2,800	2,930	3,050	3,160	2,670	2,600	2.3	10.8
38	....	....	....	....	....	....	2,180	2,430	2,640	2,860	3,040	3,180	3,310	3,440	2,865	2,790	2.6	10.3
39	....	....	....	....	....	....	2,350	2,640	2,890	3,110	3,280	3,440	3,580	3,730	3,070	2,980	2.3	11.1
40	....	....	....	....	....	....	2,530	2,860	3,140	3,360	3,550	3,730	3,880	4,040	3,280	3,180	2.9	12.3
41	....	....	....	....	....	....	2,740	3,090	3,360	3,610	3,820	4,010	4,180	4,350	3,500	3,390	3.2	11.9
42	....	....	....	....	....	....	2,980	3,280	3,570	3,840	4,080	4,300	4,500	4,690	3,750	3,620	3.7	9.7
43	....	....	....	....	....	....	3,200	3,500	3,780	4,060	4,320	4,585	4,820	5,050	4,030	3,870	3.9	12.0
44	....	....	....	....	....	....	3,420	3,720	4,010	4,310	4,600	4,880	5,140	5,400	4,340	4,140	4.6	10.6
45	....	....	....	....	....	....	....	....	4,240	4,560	4,880	5,170	5,450	5,700	4,660	4,450	4.5	12.6
46	....	....	....	....	....	....	....	....	....	4,800	5,120	5,440	5,730	5,990	5,000	4,800	4.0	12.6
47	....	....	....	....	....	....	....	....	....	5,000	5,360	5,680	5,980	6,280	5,320	5,160	3.2	12.7
48	....	....	....	....	....	....	....	....	....	....	5,600	5,920	6,230	6,540	5,600	5,480	2.2	13.2
49	....	....	....	....	....	....	....	....	....	....	5,810	6,130	6,450	6,760	5,860	5,720	2.4	13.6
50	....	....	....	....	....	....	....	....	....	....	6,000	6,340	6,660	6,970	6,080	5,880	3.3	14.4

APPENDIX C.

INSTRUCTIONS FOR MARKING TIMBER IN THE YELLOW PINE REGION, DISTRICT 6.

East of the Cascade Mountains in Oregon and Washington, the commercial forests, consist largely of yellow pine, either in pure stands or in mixed stands with Douglas fir, white and grand fir, western larch, and lodgepole pine.

Since these forests are primarily uneven-aged, they should be managed by the selection system (or a modified form of the selection system). It should be the aim, therefore, to cut over each portion of these forests periodically. From the data now at hand it is evident that the period between cuttings (the cutting cycle) should be about 60 years, and that no trees should be cut until they are 180 years old; i. e., the rotation should be 180 years.

The following general principles should govern the marking of timber in forests of this region:

GENERAL PRINCIPLES FOR ALL TYPES.

1. The cutting should be fundamentally an improvement cutting; and the officer who is marking the timber should decide first what is to be left, and then mark for cutting what is not reserved. His aim should be to leave the forest in the best condition for development during the coming cutting cycle, so that it will produce a good crop in the next cutting.

2. Aim to mark for cutting the thoroughly mature trees of all species and all those which will not survive and make good growth until the next cutting, 60 years hence.

3. Aim to reserve as the basis for the next crop a well-distributed stand of thrifty saplings, poles, and young standards, each of which is capable of living and growing until the next cutting. The trees which are reserved should be considered not as "seed trees," but as the nucleus of a later cutting.

4. On the average from 20 to 25 per cent of the estimated volume of the trees over 12 inches in diameter should be reserved. Where most of the timber is thoroughly mature or decadent, it may be wisdom to leave a smaller percentage; where most of the timber is young and thrifty, a much larger proportion should be reserved. In general, make the cutting as light as is consistent with allowing the logger to do practical, profitable logging, aiming thereby to extend the improvement cutting over a larger area, instead of making it a heavy cutting on only a small area.

5. An area should not be included within the limits of a timber sale in which there is not enough mature timber to make it worth the while of the logger to go into that area for the mature timber alone, thereby necessitating marking immature timber in order to make the logging profitable.

6. Do not hesitate to make the marking somewhat groupwise, if all the trees over a certain area are thoroughly ripe, except in exposed situations where gaps in the forest canopy are not desirable or where there is danger that the reproduction will be endangered. Yellow pine occurs to some extent even-aged in groups; and it will be necessary often to remove the old groups in their entirety. Avoid, however, making a clearance over an area larger than an acre.

7. Mark for cutting the following classes of trees of all species throughout the region in the following order of preference:

(*a*) All spike-topped, seriously fire-scarred, lightning-struck, or otherwise defective yet merchantable trees. Do not, however, consider that every tree that has a fire scar or a thin crown or some other deformity has got to be removed. Few perfect trees are to be found, and small basal scars or similar injuries in no way impair the health of the trees.

(*b*) All insect-infested trees.

(*c*) All suppressed trees which apparently would not thrive and make good growth even if released.

(*d*) All thoroughly mature trees of all species which apparently will not survive until the next cutting.

8. In general, the species should be favored in marking in the following order of preference: Western yellow pine, sugar pine, western larch, Douglas fir, white (or grand) fir, and lodgepole pine. The last two species should be considered forest weeds, and always marked heavily where better species are present.

The forests of this region may be, for the convenience of discussion, grouped into three classes: (A) practically pure stands of yellow pine; (B) mixed stands in which there is a good deal of yellow pine; (C) mixed stands in which there is little or no yellow pine. The marking in each type involves some considerations peculiar to that type.

A. *Practically pure stands of yellow pine.*[1]—This classification occurs on the slope type of the region east of the Cascades, and includes most of the commercial timber of this region. In addition to the kinds of trees mentioned above, in this type the following classes of yellow pines should also be removed:

1. Such of the mature yellow pines as would probably survive until the next cutting, when there is a superabundance of such trees to leave as the basis for the next cutting and to insure reproduction.
2. Young yellow pines, "bull pines," where the thinning out of a congested group is advisable.

B. *Mixed stands with some yellow pine.*—This is the kind of timber that is characteristic of the north slope subtype in the Blue Mountains. This class of land is well adapted to the growth of yellow pine; and, therefore, this species should be favored in marking in preference to all other species. Yet the species of secondary importance, Douglas fir and western larch, should not be marked heavily except where by so doing young yellow pines already in the stand will be directly benefited. This practice is advisable for two reasons: (1) At the present time Douglas fir and western larch in yellow-pine sales are undesirable to the purchaser and do not bring a price commensurate with what they will be worth in the future, and (2) it seems better to mark these secondary species lightly now and have the assurance of an early second cut than to make a heavy cutting now and as a result not obtain a second cut until the remote future, even though by the heavier cutting more yellow pine might be gotten into the future stand. In other words, do not sacrifice now any thrifty Douglas fir and larch unless the silvicultural conditions and composition of the forest is going to be directly benefited. The marking, therefore, should conform to the following principles, supplementing those under "General Principles:"

1. Consider white fir, grand fir, and lodgepole pine as forest weeds to be marked to as low a diameter as is consistent with the terms of the timber-sale contract and justice to the purchaser, both in order to strive to decrease the proportion of these species in the forest and to give place to more desirable species.
2. Consider Douglas fir and western larch not as undesirable species, but as species of secondary value.

Therefore, mark only such thrifty Douglas fir and larch as are in active competition with good yellow pines, or with superior Douglas firs and larches. For example, where a Douglas fir (or larch) and a yellow pine, both thrifty and of the same character, are growing side by side, one to be reserved and the other removed, the yellow pine should be reserved and the species of secondary value cut. In choosing between a Douglas fir and a larch, preference should be shown the larch except in situations not well adapted to this species.

C. *Stands with little or no yellow pine.*—This is the kind of timber which is typical of the transition type. Since in this type there is practically no yellow pine, stands of this character are ordinarily not included in the timber sales in the yellow-pine region except in cases where some of this type forms an inseparable part of the logging unit.

In general the procedure in marking should be the same as under "General Principles" and under "B" with these provisions:

1. Mark the inferior species—white fir, grand fir, and lodgepole pine to a low diameter limit, except that where these inferior species compose practically the whole stand, leave the thrifty trees of these species in preference to making a clearance.
2. Mark only such trees of the desirable species as would not thrive for the next 60 years and such as are a detriment to their superior associates.

APPENDIX D.

INSTRUCTIONS FOR BRUSH BURNING UNDER THE SELECTION SYSTEM OF CUTTING IN DISTRICT 6.

In most cases where the selection system is practiced in this district, i. e., throughout the yellow-pine type and most of the mixed forest types east of the Cascades, the brush is piled and burned in logging operations on the National Forests. The following instructions are issued in regard to methods of brush piling and burning, in order that this most vital and far too often poorly managed part of our administration of selection cuttings may be handled in the best possible fashion.

[1] Since sugar pine so closely resembles yellow pine in value and silvical requirement, it is adapted to the same method of treatment as the yellow pine with which it is associated.

Piling brush.—The first step in successful brush disposal is to secure good piles, and this requires the observance of the following provisions:

1. The large limbs should be lopped off the tops, so that, where piles are made on the tree tips, the brush will lie compactly.

2. Piles should be placed as far as possible from reserved trees of all sizes and from patches of reproduction of all species.

3. Piles should be made medium in size; i. e., they should not be so large that they will make a dangerously large blaze, and they should not be so small that they will be unnecessarily costly to burn or cover an unnecessarily large proportion of the ground.

4. The débris should be laid on the piles in an orderly fashion, so that they will be compact. The piles should be *piles*, and not heaps of brush.

5. Large chunks, and heavy limbs free from twigs, should not be placed on the piles. Such pieces will not burn up completely, and, if charred, will not rot quickly.

Burning the piles.—The success of the selection method of cutting as practiced in the yellow-pine region depends upon the proper burning of the brush. If it is not well done, the sale will be bad silviculturally no matter how good the marking or how much care is taken to avoid damage to reproduction and reserved trees. In order to burn the piles so that the least possible damage to the forest will be done, the following points should be observed, whether the burning is done by the purshaser under the direction of the forest officer or directly by the Forest Service.

1. Each burning crew should consist of but four or five men, who should be in charge of an intelligent, careful foreman. In every case there should be a forest officer to each two crews, and he should be on the ground supervising the burning most of the time while it is in progress.

2. The lighting of the piles should be done only by the foreman or some other responsible member of the crew, who will use good judgment in applying the torch.[1] At times when the brush is apt to burn freely, only every other or every third or fourth pile should be lighted, and the balance burned later or on another day, and thus the intense heat caused by burning consecutive piles will be avoided and the danger of a general conflagration lessened. Account should also be taken of the direction of the wind in relation to reserved trees, and the torch used with discretion accordingly.

The balance of the crew should "chunk up" the piles, so that a rim of unburned limbs, twigs, and needles will not be left, and should with shovels confine the fire to the space immediately about the piles.

3. The foremost consideration in brush burning is to lessen the fire menace from the logging débris in such a way that as little as possible of the reserved timber and young growth will be hurt. It is not necessary, therefore, to burn every pile, for when an occasional pile is of necessity close to young trees, it is far better to leave it than to burn it and damage them. It is also unnecessary to burn the brush absolutely clean to a bed of ashes. The coarser pieces are not a fire menace so long as all the fine twigs and needles are consumed, and though unsightly for a year or two they are not so much so as a group of scorched or dying poles and saplings. It is usually better silviculturally to have the piles burn moderately than to have them burn fiercely, and the increased cost of slow burning is amply justified.

4. In general, the fall is the best season for brush burning in practically every part of the district. On all sales, therefore, all the brush piles which have accumulated to date should be burned in the fall and early winter. In large sales where logging is in progress during the winter and early spring, in order to avoid carrying through the dry season a large quantity of brush piles, it may be best to do some spring brush burning. In any event, where a large quantity of brush is on hand in the spring, strips of brush piles should be burned for fire lanes. Begin fall burning as soon as the woods are wet enough, and spring burning as soon as the piles are dry enough. The burning seasons are short and should be made the most of.

5. The key to successful brush burning is the selection of exactly the right time to do the burning. When the season is right for burning, prompt action should be taken to get the burning crew on the ground. The weather for each day must be considered. On windy days or during the hot middays, if the burning can not be done without danger or damage to young growth, it must be discontinued until conditions are right. On some steep brushy slopes, burning may be safe only when the brush is rather wet or when snow is on the ground. In short, use judgment in selecting the day and the time of day for burning each part of a slashing; i. e., do it only at such times as will insure the best silvicultural results, and the administration of the crew should be so arranged as to accomplish this, even though to do so increases the cost of the brush disposal.

[1] A convenient brush-burning torch has been devised by one of the supervisors. It consists of a piece of light 2-inch pipe, 18 inches long, with a detachable cap or headstop at one end, which is fitted through a reducer to a piece of ⅜ or ½ inch pipe 30 inches long. Through the small pipe is run a cotton wick of the same size, its lower end being bent into convenient shape. The large pipe answers as a tank and will hold 1 quart of coal oil.